

# **SCIENCE-X**

## **MODULE - 8**

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# ELECTRICITY

## ELECTRIC CHARGE

- (A) Definition:** Electric charge may be defined as the intrinsic property of certain fundamental particles (electron, proton, etc) due to which they produce electric and magnetic effects.
- (B) Charge on a Macrobody:** Excess or deficiency of electrons in a body is equal to the charge on a macrobody. A body having excess of electrons is negatively charged and a body having deficiency of electrons is positively charged.

From the study of atomic structure, we know that an atom consists of a central part called nucleus and around the nucleus there are a number of electrons revolving in different paths or orbits. The nucleus contains protons and neutrons. A proton is a positively charged particle while a neutron has no charge. Therefore, the nucleus of an atom bears a positive charge. An electron is a negatively charged particle having negative charge equal to the positive charge on a proton. Normally, the number of electrons is equal to the number of protons in an atom. Therefore, an atom is neutral as a whole; the negative charge on electrons cancelling the positive charge on protons. This leads to the conclusion that under ordinary conditions, a body is neutral i.e. it exhibits no charge.

When this equity or balance is disturbed by removing or supplying electrons, the body acquires a net charge. The body will acquire a positive or negative charge depending upon whether electrons are removed from it or added to it.

- (C) Types of Electric Charge:** There are two types of charges. They are:

- (i) Positive charge: A body having deficiency of electrons.
- (ii) Negative charge: A body having excess of electrons.

- (D) Charging of a Body:** There are a number of methods to charge a body as:

- (i) Charging by friction
- (ii) Charging by conduction
- (iii) Charging by induction etc.

**We will discuss charging by friction in detail:**

Whenever two bodies (at least one non conductor) are rubbed against each other, heat is produced due to friction present between them. Due to this heat produced, electrons in both the bodies are excited. The body having more electron affinity attracts some of the electrons from other body. Both the bodies develop equal and opposite charges by this method.

S.No.	Positive charge	Negative Charge
1	Glass Rod	Silk cloth
2	Fur or woolen cloth	Ebonite, Amber, Rubber rod
3	Woolen coat	Plastic seat
4	Woolen carpet	Rubber shoes
5	Nylon or Acetate	Cloth
6	Dry hair	Comb

- (E) Properties of Electric Charge:**

- (i) Like charges repel and unlike charges attract each other.
- (ii) Charge is a scalar quantity.
- (iii) Charge is always quantized.
- (iv) Charge is conserved.
- (v) Charge is always associated with mass.



- (F) Unit of Charge:** The charge on an electron is so small that it is not convenient to select it the unit of charge. In practice, coulomb is used as the unit of charge, i.e. SI unit of charge is coulomb abbreviated as C. One coulomb of charge is equal to the charge on  $625 \times 10^{16}$  electrons.

**1 coulomb = charge on  $625 \times 10^{16}$  electrons or  $6.25 \times 10^{18}$  electrons**

Thus, when we say that a body has a positive charge of one coulomb (i.e + 1C) it means that the body has a deficit of  $625 \times 10^{16}$  electrons from the normal due share.

### Newton's Thought

If a neutral body is made positively charged, is there any change in its mass?

#### **Explanation**

In charging any neutral body, the mass of a body changes, though the change is extremely small or negligible. If a neutral body is made positive, it means electrons are removed from it. Thus, the mass of body decreases.

## **STATIC AND CURRENT ELECTRICITY**

- (A) Static Electricity:** A branch of physics which deals with the study of the electric charges at rest and their effects is known as electrostatic or static electricity.
- (B) Current Electricity:** A branch of physics which deals with the study of the electric charges in motion and their effects is known as current electricity.

## **ELECTRIC FIELD AND ELECTRIC POTENTIAL**

- (A) Electric Field:** Electric field due to a given charge is defined as the space around the charge in which electrostatic force of attraction or repulsion due to charge can be experienced by any other charge. If a test charge experiences no force at a point, the electric field at that point must be zero. Electric field intensity at any point is the strength of electric field at that point. It is defined as the force experienced by unit positive charge placed at that point. If F is the force acting on a test charge  $+q_0$  at any point r, then electric field intensity at this point is given by

$$E = \frac{F}{q_0}$$

Electric field is a vector quantity and its S.I. unit is Newton per coulomb or N/C.

- (B) Electric Potential:** The electric potential at a point in an electric field is defined as the amount of work done in moving a unit +ve charge from infinity to that point, without acceleration or without a change in K.E. against the electric force Mathematically,

$$V = \frac{W}{q}$$

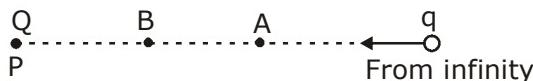
Since work is measured in joule and charge in coulomb, therefore electric potential is measured in joule per coulomb (J/C). This unit occurs so often in our study of electricity, so it has been named as volt, in honour of the scientist Alessandra Volta (the inventor of the voltaic cell).

$$1 \text{ Volt} = \frac{1 \text{ joule}}{1 \text{ coulomb}}$$

Potential is a scalar quantity, therefore it is added algebraically. For a positively charged body potential is positive and for a negatively charged body potential is negative.



**(C) Electric Potential Difference:** Consider a charge Q placed at a point P. Let A and B be two other points (B being closer to A) as shown in figure.



If a charge q is brought from infinity to A, work  $W_A$  will be done.

$$\text{The potential at A will then be, } V_A = \frac{W_A}{q}$$

If charge q is brought from infinity to B, the work done will be  $W_B$ .

$$\text{The potential at B will then be, } V_B = \frac{W_B}{q}$$

The quantity  $V_B - V_A$  is called the potential difference between points A and B in the electric field of charge Q. Mathematically we have,

$$V_B - V_A = \frac{W_B}{q} - \frac{W_A}{q}$$

Electric potential difference is also measured in volt.

## ELECTRICITY

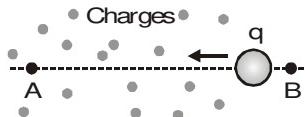
The source of all electricity is charge. As charge is the basis of all electrical phenomena, we need to know the amount of charge on a body. It is measured in coulombs. The coulomb is the SI unit of charge and its symbol is C.

Matter is generally made of protons, electrons and neutrons. Each proton carries a charge of  $1.6 \times 10^{-19}$  coulomb, and each electron carries an equal negative charge. Neutrons do not carry any net charge. Normally, a body has equal number of protons and electrons, and is therefore, electrically neutral. In certain situations, the balance of charges in a body is disturbed.

**For example:-** when a glass rod is rubbed with a silk cloth, some electrons get transferred from the glass rod to the silk. The silk cloth, which gains electrons, becomes negatively charged. And the glass rod, which is left with more protons than electrons, becomes positively charged.

Charged particles or objects can exert forces on each other. While like (similar) charges repel each other, unlike charges attract. Another important thing about charged particles is that they can flow, i.e., they can move in a particular direction. This flow of charged particles is called an electric current. Charged particles such as electrons are present in all substances. But they do not flow on their own. For flow of charges, there has to be a potential difference.

## POTENTIAL DIFFERENCE AND THE FLOW OF CHARGE



The potential difference between two points A and B is the work done per unit charge in taking a charge from B to A. We express this mathematically as

$$V = V_A - V_B = \frac{W}{q}$$

Here, V is the potential difference between the points A and B, and  $V_A$  and  $V_B$  are the potentials at these points. **The potential at infinity is chosen as zero.**



If B be the reference point, the potential at B is  $V_B = 0$ . From Equation, the potential at A is  $V_A = W/q$ . So, the potential at a point is the work done per unit charge in taking a charge to that point from a chosen reference point. Equation may also be written as

$$W = qV.$$

The work done on the charge q is stored as the electric potential energy (U) of the group of charges. So,

$$U = qV$$

#### ◆ UNIT OF POTENTIAL DIFFERENCE

The unit of potential difference (and potential) is the volt, whose symbol is V. One volt is the potential difference between two points in a current carrying conductor when 1 joule of work is done to move a charge of 1 coulomb from one point to the other.

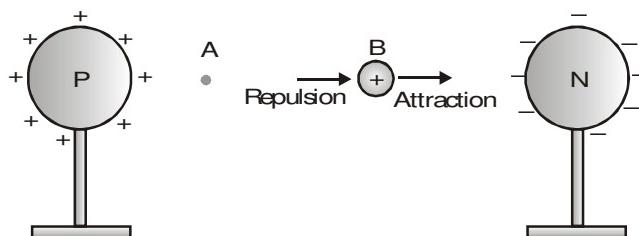
$\frac{1 \text{ Joule}}{1 \text{ Coulomb}} = 1 \text{ volt or } 1 \text{ V} = 1 \text{ JC}^{-1}$
--

The potential difference between two points is sometimes also called the voltage.

### FLOW OF CHARGE

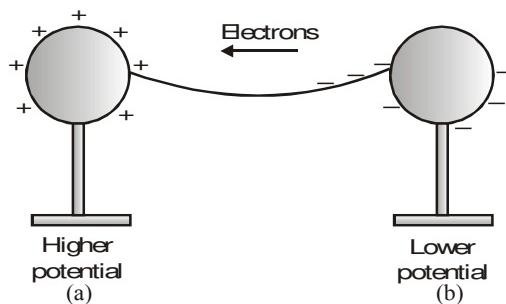
Consider two identical metallic spheres P and N, carrying equal amounts of positive and negative charges respectively. A positive charge is to be taken from B to A. It is attracted by the negatively charged sphere N and repelled by the positively charged sphere P. So, to move the charge towards A, one has to apply a force on it towards the left. Thus, the work done is positive. Hence, the potential difference  $V_A - V_B$  is positive. This means  $V_A > V_B$ .

As one moves towards P, the work done increases; so, the potential increases. And on moving towards N, the potential decreases. So, the potential of P is higher than that of N. In general, the potential of a positively charged body is taken as higher than that of a negatively charged body.



What happens when a free-to-move charge is placed between the spheres? A positive charge will move towards the negatively charged sphere. And a negative charge will move towards the positively charged sphere. That is, a free positive charge moves towards lower potential. And a free negative charge moves towards higher potential.

If the two spheres are connected by a metal wire, electrons from the negatively charged sphere (at a lower potential) will flow to the positively charged sphere (at a higher potential). Eventually, the flow of electrons causes the charges on the spheres to become balanced. When that happens, the spheres no longer carry a net charge, and therefore, have equal potential. So, the flow of electrons stops. So we can say that **a potential difference causes charges to flow**.



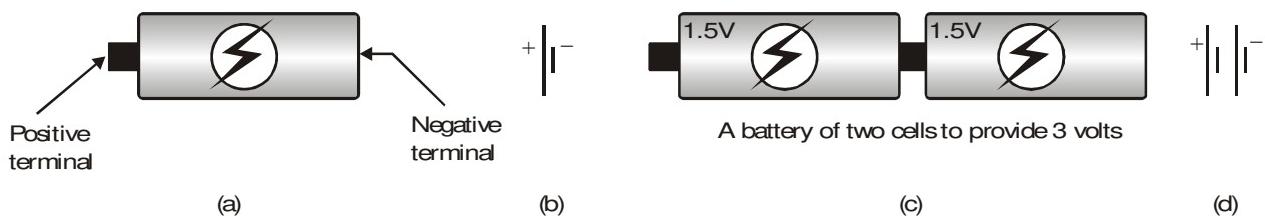
#### ◆ A CELL PROVIDES A CONSTANT POTENTIAL DIFFERENCE

The potential difference provided by things like charged spheres reduces to zero quickly once charges start to flow. So, we have to use cells to provide constant potential difference for a long time. Cells have chemicals inside. Reactions in the cell cause positive and negative charges to gather separately. This creates a potential difference between the terminals of the cell. The terminal at a higher potential is called the positive terminal and the one at a lower potential is called the negative terminal.

The cells that we commonly use are called dry cells (Figure). In a common dry cell, the small metallic cap at one end is the positive terminal, while the flat metallic plate at the other end is the negative terminal. It provides a potential difference of 1.5 V. A cell is represented by the symbol shown in fig (b). The larger line represents the positive terminal, while the shorter line represents the negative terminal.

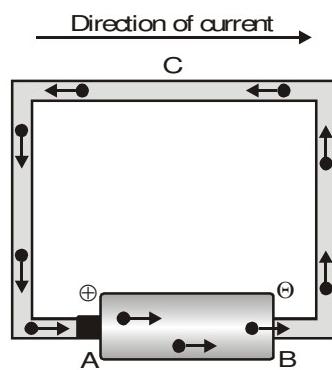
#### ◆ A COMBINATION OF CELLS IS CALLED A BATTERY

Quite often, multiple cells are combined to get a potential difference that is higher than that of a single cell. For example, we connect two 1.5V cells to get a potential difference of 3V (Figure (c)) This is shown using symbols in Figure (d).



## ELECTRIC CURRENT

Consider a metallic wire ACB connected across a cell of potential difference V. Since the end A is connected to the positive terminal, it is at a higher potential than the end B. In metals, some electrons are loosely bound to the atoms, and can move within it. These are called free electrons. In the metallic wire, these electrons (negative charges) move from the low-potential side B to the high-potential side A. After reaching A, they enter the cell. The chemical reactions in the cell drive these electrons to the negative terminal. From there, they re-enter the wire at the end B. Thus, there is a continuous flow of electrons in the wire from B to C to A. We say that there is an electric current in the wire. In a metal, the flow of negative charges constitutes the current.



Current in a wire connected to a cell

An electric current can also be a flow of positive charges. So, a flow of charge is called an electric current. By convention, the direction of current is taken as the direction of flow of positive charges. Thus, the direction of current is opposite to the direction of flow of negative charges. So, **when a wire is connected to a cell, the current in the wire is from the positive-terminal end to the negative-terminal end.**



## ◆ MEASUREMENT OF CURRENT

The charge passing per unit time through a given place(area) is the magnitude of the electric current at that place. Thus,

$$i = \frac{Q}{t}$$

Here Q is the charge that passes through a place in time t.

**Unit of current** From Equation, we find that current is charge divided by time. The SI unit of charge is the coulomb and that of time is the second. The SI unit of current, therefore, is **coulomb / second**. This unit is called the **ampere**, whose symbol is **A**.

Thus, if one coulomb of charge passes through a place in one second, the current there is 1 ampere.

## ◆ CONDUCTORS AND INSULATORS

Materials that conduct electricity easily are called good conductors or simply, conductors. And, materials that do not conduct electricity easily are called insulators.

All metals conduct electricity because they have some loosely bound free electrons, which flow when a potential difference is applied. However, some metals conduct electricity better than others. Silver is the best conductor. But because of the high cost of silver, electric wires are made of copper, or in some cases aluminium.

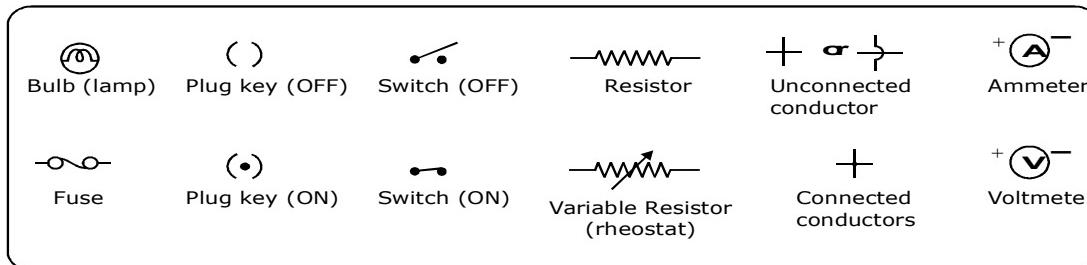
Most nonmetallic solids do not conduct electricity. Although diamond and graphite are both forms of carbon (a nonmetal), graphite is a conductor while diamond is an insulator. Insulators do not conduct electricity because their electrons are tightly bound to the atoms. Rubber, plastics, wood, glass and porcelain are some examples of insulators. Insulators have many uses. For example, they are used as protective covers on electric wires and electrician's tools.

Certain liquids also conduct electricity. While distilled water is an insulator, addition of certain salts, acids or bases allows it to conduct electricity. Under normal circumstances, gases do not conduct electricity.

## ELECTRIC CIRCUITS AND MEASURING INSTRUMENTS

**A closed path in which a current can flow is called an electric circuit.** An electric circuit may have one or more electric elements such as bulbs (or lamps), cells, switches (or plug keys), metal wires, etc. Each element of a circuit has a specific function to play. For example, wires can be used to connect one element to the next. And a plug key or a switch can be used to either complete or break the closed path, thereby starting or stopping the current in the circuit.

**Some common circuit elements and their symbols are shown in Figure.**



**Fig. Some symbols used in circuit diagrams**

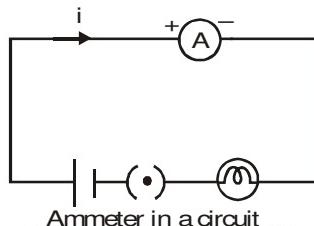
## COMMON MEASURING INSTRUMENTS

**The electric current in a circuit is measured by an instrument called the ammeter, and the potential difference between two points in it is measured by a voltmeter (in voltage stabilizers).** In these meters, a needle moving over a graduated scale gives the value of the measured quantity. Each meter has two terminals. The terminal marked '+' is connected by a wire to the higher-potential side of a circuit, while the terminal marked '-' is connected to the lower-potential side.



◆ **USING AN AMMETER TO MEASURE CURRENT**

To measure the current through an element of a circuit, an ammeter is connected in such a way that the current flowing through it also flows through the element. Such a connection is called a series connection. In Figure, the current  $i$  flowing through the lamp also flows through the ammeter. The reading of the ammeter gives the current through the lamp. Note that if the ammeter is removed, there will be a gap, and the current through the circuit will stop.

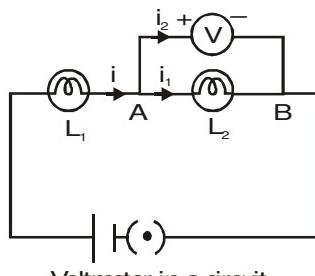


**Two or more electric elements are said to be connected in series if the current flowing through one also flows through the rest.**

**An ammeter is always connected in series in a circuit.**

◆ **USING A VOLTMETER TO MEASURE POTENTIAL DIFFERENCE**

Figure shows a circuit that has two lamps connected to a cell. We want to measure the potential difference across the lamp  $L_2$ , i.e., between the points A and B. As A is on the side of the positive terminal of the cell, its potential is higher than that of B. So, the '+' terminal of the voltmeter is connected to A, and the '-' terminal, to B. The reading of the voltmeter gives the potential difference across  $L_2$ . The current flowing through the voltmeter is different from those flowing through the other elements of the circuit. Also, even if the voltmeter is removed, the current continues to flow in the circuit. Note that the potential difference across  $L_2$  and the voltmeter is the same. Such a connection is called a parallel connection.



**Two or more electric elements are said to be connected in parallel if the same potential difference exists across them.**

### OHM'S LAW

The electric current through a metallic element or wire is directly proportional to the potential difference applied between its ends, provided the temperature remains constant.

If a potential difference  $V$  is applied to an element and a current  $i$  passes through it,

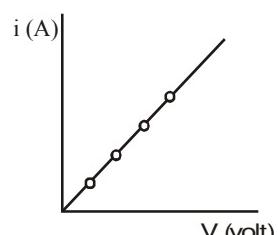
$$i \propto V$$

$$\text{or } i = \left( \frac{1}{R} \right) V$$

$$V = iR$$

Thus **Ohm's Law**

$$1\text{ohm} = \frac{1\text{ volt}}{1\text{ ampere}}$$



Here  $R$  is a constant for the given element (metallic wire) at a given temperature and is called its resistance. It is the property of a conductor to resist the flow of charges through it.



## RESISTANCE

From equation,

$$i = \frac{V}{R}$$

So, for a given potential difference,

$$i \propto \frac{1}{R}$$

Thus, for a given potential difference, the current is inversely proportional to the resistance. The higher is the resistance, the lower is the current. If the resistance is doubled, the current is halved. Good conductors have low resistance, while insulators have very high resistance.

### ◆ UNIT OF RESISTANCE

Potential difference is measured in volts, and current is measured in amperes. From Equation,  $R = V/i$ . So, the unit of resistance is **volt/ampere**. This unit is called the **ohm**, and its symbol is  $\Omega$ . We can define one ohm as follows.

If a potential difference of 1 volt is applied across an element, and a current of 1 ampere passes through it, the resistance of the element is called 1 ohm.

### ◆ ON WHAT DOES RESISTANCE DEPEND ?

The resistance of the conductor depends on:

- (i) on its length
- (ii) on its area of cross-section
- (iii) on the nature of its material
- (iv) Resistance depends on temperature (resistance increases with increase in temperature)

Resistance of a uniform metallic conductor is directly proportional to its length ( $\ell$ ) and inversely proportional to the area of cross-section (A).

$$R \propto \ell \quad \text{and} \quad R \propto \frac{1}{A}$$

Combining eqs. we get

$$R \propto \frac{\ell}{A} \quad \text{or} \quad R = \rho \frac{\ell}{A}$$

Where  $\rho$  (**rho**) is a constant of proportionality and is called electrical resistivity of the material of the conductor.

◆ **RESISTIVITY ( $\rho$ ) :** Here,  $\rho$  is a constant for a given material at a given temperature. It is called the resistivity of the material. the resistivity of a material is the resistance per unit length of a unit cross section of the material. The SI unit of a material depends on its temperature. For metals and alloys of metals, the resistivity increases with rise in temperature. The SI unit of resistivity is  $\Omega \text{ m}$ .

Material	Resistivity ( $\Omega \text{ m}$ )
Metals	Silver
	Copper
	Aluminium
	Tungsten
	Iron
Alloys	Manganin
	Nichrome
Semiconductors	Germanium
	Silicon
Insulators	Diamond
	Fused quartz



### Newton's Thought

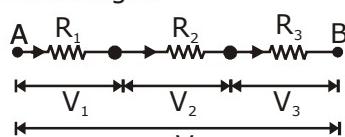
Two materials have different resistivities. Two wires of the same length are made, one from each of the materials. Is it possible for each wire to have the same resistance?

#### **Explanation**

Two wires of the same length are made, one from each of the materials. The resistance of a wire is given by,  $R = \rho \frac{l}{A}$  where  $\rho$  is the resistivity of the wire material, and  $l$  and  $A$  are respectively, the length and cross-sectional area of the wire. Even when the wires have the same length, they may have the same resistance, if the cross-sectional areas of the wires are chosen so that the ratio  $\frac{\rho}{A}$  is the same for each. That is

$$\rho_1 \frac{l}{A_1} = \rho_2 \frac{l}{A_2} \text{ or } \frac{A_2}{A_1} = \frac{\rho_2}{\rho_1}$$

This is the condition for each wire of different materials to have the same resistance when they have same length.



**A series combination of resistors**

## **SERIES AND PARALLEL CONNECTIONS OF RESISTORS**

A conducting material (e.g., a wire) of a particular resistance meant for use in a circuit is called a resistor. A resistor is sometimes simply referred to as a resistance. It is represented by the symbol . Two or more resistors can be connected in series, in parallel or in a manner that is a combination of these two.

### **1. SERIES CONNECTION OF RESISTORS**

Two or more resistors are said to be connected in series if the current flowing through one also flows through the rest.

The total potential difference across the combination of resistors connected in series is equal to the sum of the potential differences across the individual resistors.

$$V = V_1 + V_2 + V_3$$

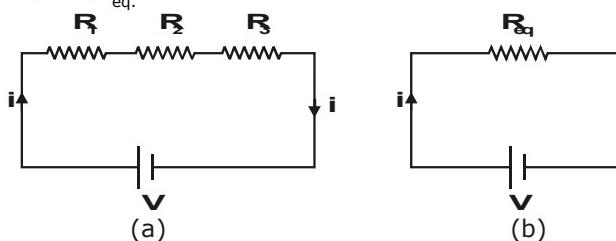
#### **◆ EQUIVALENT RESISTANCE IN SERIES CONNECTION**

Figure (a) shows three resistors of resistances  $R_1$ ,  $R_2$  and  $R_3$  connected in series. The cell connected across the combination maintains a potential difference  $V$  across the combination. The current through the cell is  $i$ . The same current  $i$  flows through each resistor.

Let us replace the combination of resistors by a single resistor  $R_{eq}$  such that the current does not change, i.e., it remains  $i$ . This resistance is called the **equivalent resistance** of the combination, and its value is given by Ohm's law as  $R_{eq} = V/i$

Thus

$$V = iR_{eq}$$



The potential differences  $V_1$ ,  $V_2$  and  $V_3$  across the resistors  $R_1$ ,  $R_2$  and  $R_3$  respectively are given by Ohm's law as :

$$V_1 = iR_1, V_2 = iR_2, V_3 = iR_3$$

Since the resistors are in series,  $V = V_1 + V_2 + V_3$

Substituting the values of the potential differences in the above equation,

$$iR_{eq} = iR_1 + iR_2 + iR_3$$

or

$$iR_{eq} = i(R_1 + R_2 + R_3)$$

or

$$R_{eq} = R_1 + R_2 + R_3$$

Similarly, for  $n$  resistors connected in series,

**Equivalent resistance of resistors in series :**  $R_{eq} = R_1 + R_2 + R_3 + \dots + R_n$

## 2. PARALLEL CONNECTION OF RESISTORS

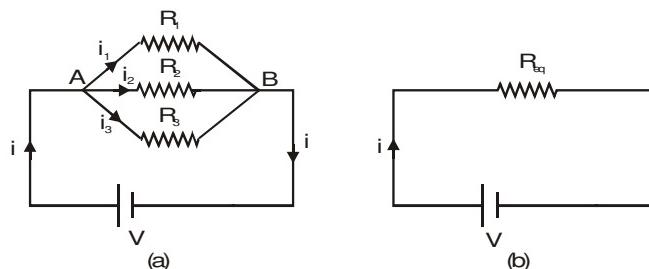
The total current flowing into the combination is equal to the sum of the currents passing through the individual resistors.

$$i = i_1 + i_2 + i_3$$

If resistors are connected in such a way that the same potential difference gets applied to each of them, they are said to be connected in parallel.

### ◆ EQUIVALENT RESISTANCE IN PARALLEL CONNECTION

Figure (a) shows three resistors of resistances  $R_1$ ,  $R_2$  and  $R_3$  connected in parallel across the points A and B. The cell connected across these two points maintains a potential difference  $V$  across each resistor. The current through the cell is  $i$ . It gets divided at A into three parts  $i_1$ ,  $i_2$  and  $i_3$ , which flow through  $R_1$ ,  $R_2$  and  $R_3$  respectively.



Let us replace the combination of resistors by an equivalent resistor  $R_{eq}$  such that the current  $i$  in the circuit does not change (Fig). The equivalent resistance is given by Ohm's law as  $R_{eq} = V/i$ .

Thus,

$$i = \frac{V}{R_{eq}}$$

The currents  $i_1$ ,  $i_2$  and  $i_3$  through the resistors  $R_1$ ,  $R_2$  and  $R_3$  respectively are given by Ohm's law as

$$i_1 = \frac{V}{R_1}, \quad i_2 = \frac{V}{R_2}, \quad i_3 = \frac{V}{R_3}$$

Since the resistors are in parallel,

$$i = i_1 + i_2 + i_3$$



Substituting the values of the currents in the above equation,

$$\frac{V}{R_{eq}} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

or

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Similarly, if there are  $n$  resistors connected in parallel, their equivalent resistance  $R_{eq}$  is given by

**Equivalent Resistance of resistors in parallel :**  $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_n}$

For two resistances  $R_1$  and  $R_2$  connected in parallel,

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_1 + R_2}{R_1 R_2}$$

or

$$R = \frac{R_1 R_2}{R_1 + R_2}$$

The equivalent resistance in a parallel connection is less than each of the resistances.

When a resistance is joined parallel to a comparatively smaller resistance, the equivalent resistance is very close to the value of the smaller resistance.

**NOTE :** If a resistor connected in series with others is removed or fails, the current through each resistor becomes zero. On the other hand, if a resistor connected in parallel with others fails or is removed, the current continues to flow through the other resistors.

#### ◆ DISTRIBUTION OF CURRENT IN TWO RESISTORS IN PARALLEL

Consider the circuit in fig. The resistors  $R_1$  and  $R_2$  are connected in parallel. The current  $i$  gets distributed in the two resistors.

$$i = i_1 + i_2 \quad \dots \dots \text{(i)}$$

Applying Ohm's law to the resistor  $R_1$

$$V_A - V_B = R_1 i_1 \quad \dots \dots \text{(ii)}$$

And applying Ohm's law to the resistor  $R_2$

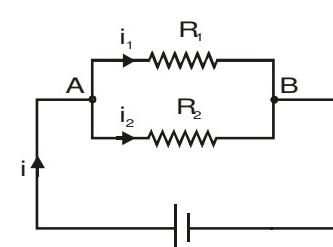
$$V_A - V_B = R_2 i_2 \quad \dots \dots \text{(iii)}$$

From (ii) and (iii),  $R_1 i_1 = R_2 i_2$  or  $i_2 = \frac{R_1}{R_2} i_1$

Substituting for  $i_2$  in (i), we have

$$i = i_1 + \frac{R_1}{R_2} i_1 = i_1 \left(1 + \frac{R_1}{R_2}\right) = i_1 \frac{R_1 + R_2}{R_2}$$

$$\text{or } i_1 = \frac{R_2}{R_1 + R_2} i$$



Similarly,

$$i_2 = \frac{R_1}{R_1 + R_2} i$$

Thus,

$$\frac{i_1}{i_2} = \frac{R_2}{R_1}$$

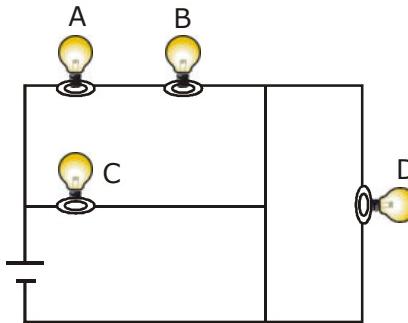
The current through each branch in a parallel combination of resistors is inversely proportional to its resistance.

### Newton's Thought

Figure shows a combination of four identical bulbs joined with a battery. Compare the brightness of the bulbs shown. What happens if bulb A fails, so that it cannot conduct current? What happens if bulb C fails? What happens if bulb D fails?

#### **Explanation**

Bulbs A and B are connected in series across the emf of the battery, whereas bulb C is connected by itself across the battery. This means the voltage drop across C has the same magnitude as the battery voltage, whereas this same voltage is split between bulbs A and B. As a result, bulb C will glow more brightly than either of bulbs A and B, which will glow equally brightly. Bulb D has a wire connected across it i.e., a short circuit, so that potential difference across bulb D is zero and it doesn't glow. If bulb A fails, B goes out, but bulb C will glow. If bulb C fails, there is no effect on the other bulbs. If bulb D fails we cannot detect this event, because bulb D was not glowing initially; also, there is no effect on the other bulbs.



## **DEVICES IN SERIES AND PARALLEL**

You must have seen tiny bulbs strung together for decorating buildings during festivals like Diwali, and occasions like marriages, etc. These bulbs are connected in series, and the mains voltage is applied to the combination. The potential difference ( $V$ ) of the mains gets divided across the bulbs ( $V = V_1 + V_2 + V_3 + \dots$ ). So, a small potential difference exists across each bulb, close to that required to make the bulb work. However, the same current flows through all the bulbs. So, if one bulb goes bad, the current through it stops, and this stops the current through the rest of the bulbs as well. To make the chain of lights work, we have to find and replace the defective bulb. This problem does not occur with the lights in our house. That is because **in houses, lights, fans, etc., are connected in parallel**. In parallel connection, the same mains voltage gets applied to each device, but the current through each is different. If one of them goes bad, the current in the other branches of the parallel connection does not stop. Another advantage of parallel connection is that, unlike series connection, each device can draw a different current, as per its requirement.

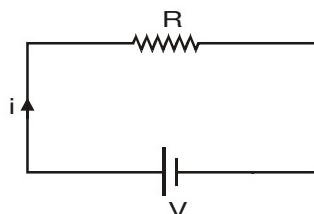


## HEATING EFFECT OF ELECTRIC CURRENT

When an electric current passes through a bulb, the filament gets so hot that it glows and emits light. When a current passes through the filament of an electric iron, the iron becomes very hot. This increase in temperature is due to what is called 'the heat produced due to current'. Suppose a resistor  $R$  is connected to a cell. The cell maintains a potential difference  $V$  across the resistor, driving a current  $i$  through it.

So,

$$V = iR \quad \dots\dots(i)$$



The current through the resistor is actually a flow of negative charges (electrons). Inside the cell, the negative charges flow from the positive to the negative terminal. The cell does work  $= QV$  to take a charge through the potential difference  $V$  between its terminals. This increases the energy of the charge by  $QV$ . This increased energy gets converted to heat in the resistor. So, the energy appearing as heat is given by

$$U = QV \quad \dots\dots(ii)$$

The charge that passes through the wire in time  $t$  is

$$Q = it. \quad \dots\dots(iii)$$

Using (i), (ii) and (iii), we find that the heat produced in the wire in time  $t$  is

$$U = QV = (it)(iR) = i^2 Rt.$$

From Equation the heat produced is proportional to the square of the current, if  $R$  and  $t$  remain constant. So, if the current passing for a given time through a given resistance is doubled, the heat produced becomes four times. Similarly, for a given  $i$  and  $t$ , the heat produced is proportional to  $R$ . If the same current  $i$  passes through two resistances in a given time, more heat will be produced in the larger resistance. The heat produced can also be written as.

$$U = i^2 Rt = \left(\frac{V}{R}\right)^2 Rt$$

or

$$U = \frac{V^2 t}{R}$$

For a given  $V$  and  $t$ , the heat produced is inversely proportional to  $R$ . So, if the same potential difference is applied across two resistances, more heat will be produced in the smaller resistance.

We have seen above that the increased energy of a charge gets converted to heat in the resistor. The increase in energy comes from the work done by the cell. This uses up the chemical energy of the cell. So, the energy appearing as heat in the resistor ultimately comes at the expense of the chemical energy of the cell.

Not always is the work done by a cell converted to heat. Immediately after a motor is connected to a cell, the speed of the shaft of the motor increases. A part of the work done by the cell goes into producing the increase in kinetic energy. And a part is used to overcome friction, etc. When the motor achieves a constant speed, its kinetic energy does not change. So the work done by the cell is only used to overcome friction, etc. This appears as heat. That is why the cover over a motor becomes warm on use.



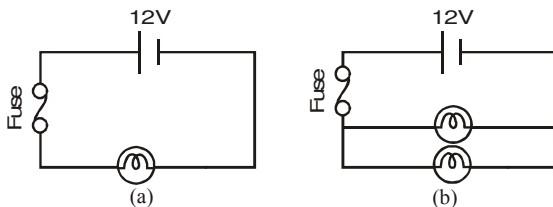
## APPLICATIONS OF THE HEATING EFFECT OF CURRENT

The heating effect of electric current has many uses. Electric bulbs, room heaters, electric irons, immersion heaters, toasters, electric fuses and a number of other appliances work on this principle. In all of these, a wire of suitable resistance, commonly called the heating element, is connected to the power supply. The current passing through the element produces heat in it, which is used for some specific purpose.

- (i) **Electric bulb:** An electric bulb has a simple structure. It consists of a sealed glass bulb that has a tungsten filament connected to two electrical contacts. The bulb is filled with an unreactive gas like argon or nitrogen. To produce white light, the filament has to be heated to about  $3000^{\circ}\text{C}$  by passing a current through it. Obviously, the material of the filament should such that it does not melt at this temperature. Tungsten is used for the filament because its melting point is about  $3400^{\circ}\text{C}$ . The sealed glass bulb serves two purposes. First, it protects the filament from oxidation and the effects of humidity. Secondly, the small enclosed volume makes it easier to maintain the required temperature, as without it the loss of heat would be more.
- (ii) **Fuse:** A fuse is a safety device that does not allow excessive current to flow through an electric circuit. It consists of a metallic wire of low melting point, fixed between the two terminals of a fuse plug. The fuse plug fits into a fuse socket connected in the circuit. Fuses are available in various shapes. The fuse plug is used in household wiring. It is made of porcelain.

**A fuse is connected in series with an appliance** (such as a TV) or a group of appliances (such as the lights and fans in a room). So, the current through the fuse is the same as the current through the appliance or the group of appliances. If this current exceeds a safe value, the heat produced in the fuse wire causes it to melt immediately. This breaks the circuit, preventing any damage. Figure shows examples of how a fuse is connected in circuits.

Good-quality fuse wires are made of tin, as it has a low melting point. Some fuse wires are made of an alloy of tin and copper. The thickness of the fuse wire depends on the circuit in which it is to be used. If a section of the circuit is meant to carry a maximum of 5A current, the fuse wire should also be able to carry currents up to 5A. Similarly, for wiring meant for 15A, the fuse wire should be thicker, and should be able to carry currents up to 15A.



### ◆ DISADVANTAGES OF THE HEATING EFFECT OF CURRENT

A current always produces some heat, whether we use the heat or not. If the heat produced cannot be utilized, it represents a wastage of energy. A considerable amount of energy is thus wasted in the transmission of electricity from the generating station to our homes. Sometimes, the heat produced in a device is so much that it can damage the device, unless proper cooling arrangements are made. To dissipate the heat produced in TV sets, monitors, etc., their cabinets have grills for air to pass. Certain components of a computer get so hot that they have fans to cool them.



## ELECTRIC POWER

Power is the rate of doing work, or the rate at which energy is produced or consumed. The electrical energy produced or consumed per unit time is called electric power. In an electric circuit, the power is

$$P = \frac{U}{t} = \frac{i^2 R t}{t} = i^2 R$$

Using  $iR = V$

$$P = Vi$$

$$P = \frac{V^2}{R}$$

The energy consumed and power are related as

$$U = Pt.$$

### ◆ UNIT OF POWER

The SI unit of energy is the joule, and that of time is the second. The SI unit of power is therefore joule/second. This unit is called the watt, whose symbol is W.

## RATING OF ELECTRIC APPLIANCES

Take an electric bulb and see what is written on it. Apart from the name and the symbol of the company, we will find values of power and potential difference. For example, it could be 60W, 220V. It means that 220V should be applied across this bulb, and when 220V is applied, the power consumed will be 60W. We will find similar markings on all electric appliances. For an electric appliance, the values of power and voltage taken together form what is called the rating of the appliance.

⇒ From the rating of an appliance, you can easily calculate its resistance by using the equation  $P = \frac{V^2}{R}$ .

Note that higher the power rating, smaller the resistance. So, a 1000W heater has less resistance than a 100W bulb. We can also calculate the current drawn by an appliance by using the relation  $i = \frac{P}{V}$ .

### ◆ KILOWATT HOUR

Power is the rate of energy consumed or produced. If 1 joule of energy is used per second, the energy is used at the rate of 1 watt. In other words, if energy is used at the rate of 1 watt, the total energy used in 1 second is 1 joule. How much energy is used in 1 hour if it is used at the rate of 1000 watt?

**It is (1000 watt) × (3600 second) = 3,600,000 joule.**

This amount of energy is called 1 kilowatt hour, written in short as **kWh**.

Thus, **1 kWh = 3,600,000 J = 3.6 × 10<sup>6</sup> J**.

The electrical energy used in houses, factories, etc., is measured in kilowatt hours. The cost of electricity is fixed per kilowatt hour. **One kilowatt hour of electrical energy is called one unit.**



# ELECTRICAL SAFETY

- (A) Earthing:** Earthing means to connect the metal case of electrical appliance to the earth (at zero potential) by means of a metal wire called "earth wire". In household circuits, we have three wires, the live wire, the neutral wire and the earth wire. One end of the earth wire is buried in the earth. We connect the earth wire to the metal case of the electrical appliance by using a three-pinplug. The metal casing of the appliance will now always remain at the zero potential of the earth. We say that the appliance has been earthed or grounded. If, by chance, the live wire touches the metal case of the electric iron (or any other appliance) which has been earthed, then the current passed directly to the earth through the earth wire. It does not need our body to pass the current and therefore, we do not get an electric shock. Actually, a very heavy current flows through the earth wire and the fuse of house-hold wiring blows out or melts. And it cuts off the power supply. In this way, earthing also saves the electrical appliance from damage due to excessive current.

**(B) Miniature Circuit Breaker:** These days a device called a miniature circuit breaker (MCB) is also used instead of or in addition of fuses, in the household electric circuits. It is a switch that automatically switches off a circuit if the current in it exceeds the specified maximum limit.

## **COLOR CODING OF WIRES**

An electric appliance is provided with a three-core flexible cable. The insulation on the three wires is of different colours. The old convention is red for live, black for neutral and green for earth. The new international convention is brown for live, light blue for neutral and green (or yellow) for earth.

## **GALVANOMETER**

A galvanometer is an instrument that can detect the presence of a current in a circuit. The pointer remains at zero (the centre of the scale) for zero current flowing through it. It can deflect either to the left or to the right of the zero mark depending on the direction of current.

Galvanometers are of two types:



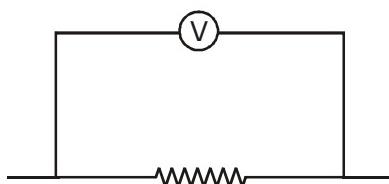
It is used to make ammeter and voltmeter as follows:

- (A) Ammeter:** Ammeter is an electrical instrument which measures the strength of current in 'ampere' in a circuitry which is always connected in series in circuit so that total current (to be measured) may pass through it. The resistance of an ideal ammeter is zero (practically it should be minimum).

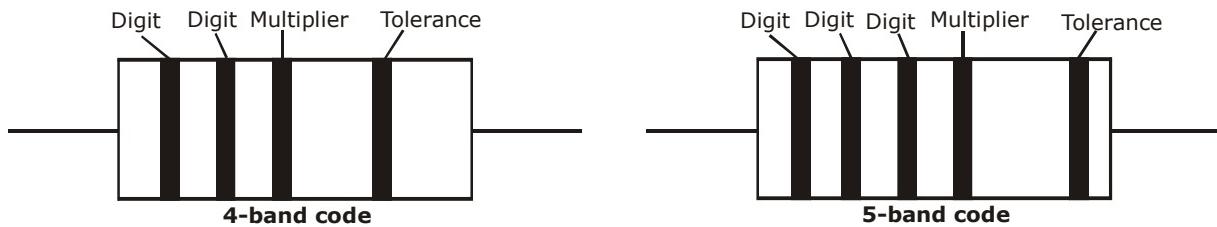
- (B) Voltmeter:** It is an electrical instrument which measures the potential difference in 'volt' between two points of electric circuit. The only difference between ammeter and voltmeter is that ammeter has its negligible (approximately zero) resistance so that it may measure current of circuit passing through it more accurately giving the deflection accordingly, while the voltmeter passes negligible current through itself so that potential difference developed due to maximum current passing through circuit may be measured.

Voltmeter has very high resistance and the resistance of an ideal voltmeter is infinite.

A voltmeter is always connected in parallel.



## COLOR CODING OF RESISTORS



Color	Digit	Multiplier	Tolerance (%)
Black	0	$10^0(1)$	
Brown	1	$10^1$	1
Red	2	$10^2$	2
Orange	3	$10^3$	
Yellow	4	$10^4$	
Green	5	$10^5$	0.5
Blue	6	$10^6$	0.25
Violet	7	$10^7$	0.1
Grey	8	$10^8$	
White	9	$10^9$	
Gold		$10^{-1}$	5
Silver		$10^{-2}$	10
(None)			20

**Note:** Short trick for colors:- B B Roy of Great Britain has very good Wife.



## SOLVED PROBLEMS

- Ex.1** A piece of wire of resistance R is cut into five equal parts. These parts are then connected in parallel. If the equivalent resistance of this combination is R', then the ratio R/R' is :  
 (A) 1/25                    (B) 1/5                    (C) 5                    (D) 25

**Sol.** Resistance of each one of the five parts =  $\frac{R}{5}$

Resistance of five parts connected in parallel is given by

$$\frac{1}{R'} = \frac{1}{R/5} + \frac{1}{R/5} + \frac{1}{R/5} + \frac{1}{R/5} + \frac{1}{R/5} \quad \text{or} \quad \frac{1}{R'} = \frac{5}{R} + \frac{5}{R} + \frac{5}{R} + \frac{5}{R} + \frac{5}{R} = \frac{25}{R}$$

$$\text{or } \frac{R}{R'} = 25$$

Thus, (D) is the correct answer.

- Ex.2** Which of the following terms does not represent electrical power in a circuit :  
 (A)  $I^2R$                     (B)  $IR^2$                     (C)  $VI$                     (D)  $V^2/R$

**Sol.** Electrical power,  $P = VI = (IR) I = I^2R = V \left( \frac{V}{R} \right) = \frac{V^2}{R}$

Obviously,  $IR^2$  does not represent electrical power in a circuit.

Thus, (B) is the correct answer.

- Ex.3** An electric bulb is rated 220 V and 100 W. When it is operated on 110 V, the power consumed will be:

(A) 100 W                    (B) 75 W                    (C) 50 W                    (D) 25 W

**Sol.** Resistance of the electric bulbs,  $R = \frac{V^2}{P}$                     ( $P = V^2/R$ )

$$\text{or } R = \frac{(220)^2}{100} = 484\Omega$$

Power consumed by the bulb when it is operated at 110 V is given by

$$P' = \frac{V'^2}{R} = \frac{(110)^2}{484} = \frac{110 \times 110}{484} = 25W \quad (V' = 100 V)$$

Thus, (D) is the correct answer.

- Ex.4** Two conducting wires of the same material and of equal lengths and equal diameters are first connected in series and then in parallel in an electric circuit. The ratio of the heat produced in series and parallel combinations would be :

(A) 1:2                    (B) 2:1                    (C) 1:4                    (D) 4:1

**Sol.** Since both the wires are made of the same material and have equal lengths and equal diameters, these have the same resistance. Let it be R.

When connected in series, their equivalent resistance is given by

$$R_s = R + R = 2R$$

When connected in parallel, their equivalent resistance is given by

$$\frac{1}{R_p} = \frac{1}{R} + \frac{1}{R} = \frac{2}{R} \quad \text{or} \quad R_p = \frac{R}{2}$$

Further, electrical power is given by  $P = \frac{V^2}{R}$

Power (or heat produced) in series,  $P_s = \frac{V^2}{R_s}$

Power (or heat produced) in parallel,  $P_p = \frac{V^2}{R_p}$

$$\text{Thus, } \frac{P_s}{P_p} = \frac{V^2 / R_s}{V^2 / R_p} = \frac{R_p}{R_s} = \frac{R / 2}{2R} = \frac{1}{4}$$

or  $P_s : P_p : : 1 : 4$

Thus, (C) is the correct answer.



**Ex.5** How is voltmeter connected in the circuit to measure potential difference between two points?

**Sol.** A voltmeter is always connected in parallel across the points between which the P.D. is to be determined.

**Ex.6** A copper wire has a diameter of 0.5 mm and a resistivity of  $1.6 \times 10^{-6}$  ohm cm. How much of this wire would be required to make a 10 ohm coil? How much does the resistance change if the diameter is doubled?

**Sol.** We are given that, Diameter of the wire,  $D = 0.5 \text{ mm} = 0.5 \times 10^{-3} \text{ m}$

resistivity of copper,  $\rho = 1.6 \times 10^{-6} \text{ ohm cm} = 1.6 \times 10^{-8} \text{ ohm m}$   
required resistance,  $R = 10 \text{ ohm}$

$$\text{As } R = \frac{\rho\ell}{A}, \ell = \frac{RA}{\rho} = \frac{R(\pi D^2 / 4)}{\rho} = \frac{\pi RD^2}{4\rho} [\text{A} = \pi r^2 = \pi(D/2)^2 = \pi D^2/4]$$

$$\text{or } \ell = \frac{3.14 \times 10 \times (0.5 \times 10^{-3})^2}{4 \times 1.6 \times 10^{-8}} \text{ m} = 112.7 \text{ m}$$

Since,  $R = \frac{\rho\ell}{\pi D^2 / 4} = \frac{r\rho\ell}{\pi D^2}$ ,  $R \propto 1/D^2$ . When D is doubled, R becomes  $\frac{1}{4}$  times.

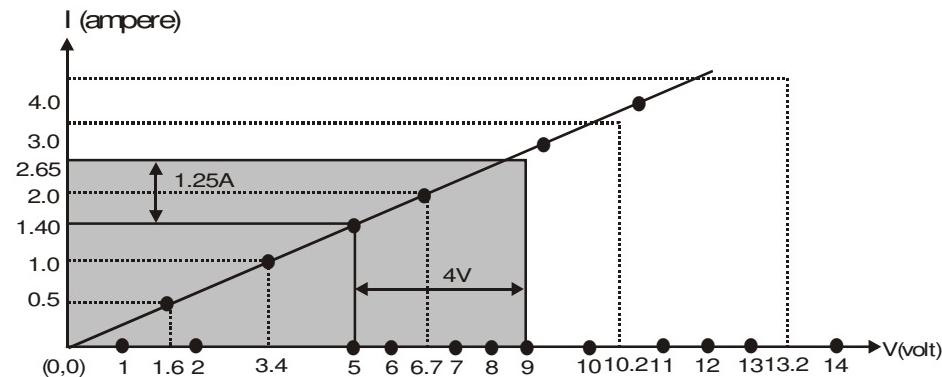
**Ex.7** The values of current, I, flowing in a given resistor for the corresponding values of potential difference, V, across the resistor are given below :

I (ampere) : 0.5 1.0 2.0 3.0 4.0

V (volt) : 1.6 3.4 6.7 10.2 13.2

Plot a graph between V and I and calculate the resistance of the resistor.

**Sol.** The V-I graph is as shown in fig.



For  $V = 4 \text{ V}$  (i.e.,  $9 \text{ V} - 5 \text{ V}$ ),  $I = 1.25 \text{ A}$  (i.e.,  $2.65 \text{ A} - 1.40 \text{ A}$ ). Therefore,  $R = \frac{V}{I} = \frac{4 \text{ V}}{1.25 \text{ A}} = 3.2 \Omega$

The value of R obtained from the graph depends upon the accuracy with which the graph is plotted.

**Ex.8** When a 12 V battery is connected across an unknown resistor, there is a current of 2.5 mA in the circuit. Find the value of the resistance of the resistor.

**Sol.** Here,  $V = 12 \text{ V}$ ,  $I = 2.5 \text{ mA} = 2.5 \times 10^{-3} \text{ A}$

$$\text{Resistance of the resistor, } R = \frac{V}{I} = \frac{12 \text{ V}}{2.5 \times 10^{-3} \text{ A}} = 4800 \Omega = 4.8 \text{ k}\Omega$$

**Ex.9** A battery of 9 V is connected in series with resistors of  $0.2\Omega$ ,  $0.3\Omega$ ,  $0.4\Omega$ ,  $0.5\Omega$  and  $12\Omega$ . How much current would flow through the  $12\Omega$  resistor?

**Sol.** Since all the resistors are in series, equivalent resistance,

$$R_s = 0.2 \Omega + 0.3 \Omega + 0.4 \Omega + 0.5 \Omega + 12 \Omega = 13.4 \Omega$$

$$\text{Current through the circuit, } I = \frac{V}{R_s} = \frac{9 \text{ V}}{13.4 \Omega} = 0.67 \text{ A}$$

In series, same current (I) flows through all the resistors. Thus, current flowing through  $12\Omega$  resistor = 0.67 A



**Ex.10** How many  $176\Omega$  resistors (in parallel) are required to carry 5 A in 220 V line?

**Sol.** Here,  $I = 5\text{A}$ ,  $V = 220\text{V}$ .

Resistance required in the circuit,  $R = \frac{V}{I} = \frac{220\text{V}}{5\text{A}} = 44\Omega$ , Resistance of each resistor,  $r = 176\Omega$

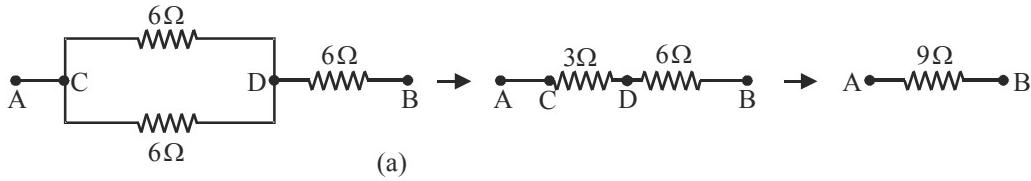
If  $n$  resistors, each of resistance  $r$ , are connected in parallel to get the required resistance  $R$ , then

$$R = \frac{r}{n}$$

$$\text{or } 44 = \frac{176}{n} \quad \text{or } n = \frac{176}{44} = 4$$

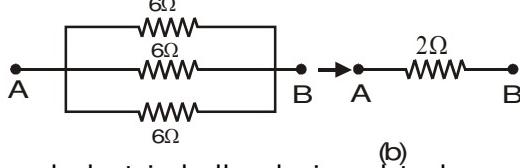
**Ex.11** Show how you would connect three resistors, each of resistance  $6\Omega$ , so that the combination has a resistance of (i)  $9\Omega$  (ii)  $2\Omega$ .

**Sol.** (i) In order to get a resistance of  $9\Omega$  from three resistors, each of resistance  $6\Omega$ , we connect two resistors in parallel and this parallel combination (or resistance  $3\Omega$ ) in series with the third resistor as shown in fig.



(ii) In order to get a resistance of  $2\Omega$  from three resistors, each of resistance  $6\Omega$ , we connect all the three resistors in parallel as shown in fig (b) as equivalent resistance in parallel combination,

i.e.,  $R_p$  is given by  $R_p = \frac{6\Omega}{3} = 2\Omega$ .



**Ex.12** Several electric bulbs designed to be used on a 220 V electric supply line, are rated 10 W. How many lamps can be connected in parallel with each other across the two wires of 220 V line if the maximum allowable current is 5 A?

**Sol.** Resistance of each bulb,  $r = \frac{V^2}{P} = \frac{(220)^2}{10} = 4840\Omega$

Total resistance in the circuit,  $R = \frac{220\text{V}}{5\text{A}} = 44\Omega$

Let  $n$  be the number of bulb (each of resistance  $r$ ) to be connected in parallel to obtain a resistance  $R$ .

$$\text{Clearly, } R = \frac{r}{n} \quad \text{or} \quad n = \frac{r}{R} = \frac{4840\Omega}{44\Omega} = 110$$

**Ex.13** A hot plate of an electric oven connected to a 220 V line has two resistance coils A and B, each of  $24\Omega$  resistance, which may be used separately, in series, or in parallel. What are the currents in the three cases?

**Sol.** Here, potential difference,  $V = 220\text{V}$

Resistance of each coil,  $r = 24\Omega$

(i) When each of the coils A or B is connected separately, current through each foil, i.e.,

$$I = \frac{V}{r} = \frac{220\text{V}}{24\Omega} = 9.2\text{A}$$

(ii) When coils A and B are connected in series, equivalent resistance in the circuit,

$$R_s = r + r = 2r = 48\Omega$$

Current through the series combination, i.e.e,  $I_s = \frac{V}{R_s} = \frac{220\text{V}}{48\Omega} = 4.6\text{A}$

(iii) When the coils A and B are connected in parallel, equivalent resistance in the circuit,

$$R_p = \frac{r}{2} = \frac{24\Omega}{2} = 12\Omega$$

Current through the parallel combination, i.e.e,  $I_p = \frac{V}{R_p} = \frac{220\text{V}}{12\Omega} = 18.3\text{A}$



**Ex.14** Compare the power used in the  $2\Omega$  resistor in each of the following circuits :

- (i) a 6 V battery in series with  $1\Omega$  and  $2\Omega$  resistors, and
- (ii) a 4 V battery in parallel with  $12\Omega$  and  $2\Omega$  resistors.

**Sol.** (i) Since 6 V battery is in series with  $1\Omega$  and  $2\Omega$  resistors, current in the circuit,

$$I = \frac{6V}{1\Omega + 2\Omega} = \frac{6V}{3\Omega} = 2A$$

Power used in  $2\Omega$  resistor,  $P_1 = I^2R = (2A)^2 \times 2\Omega = 8W$

- (ii) Since 4 V battery is in parallel with  $12\Omega$  and  $2\Omega$  resistors, pd across  $2\Omega$  resistor,  $V = 4V$ .

$$\text{Power used in } 2\Omega \text{ resistor, } P_2 = \frac{V^2}{R} = \frac{(4V)^2}{(2\Omega)} = 8W$$

$$\text{Clearly, } \frac{P_1}{P_2} = \frac{8W}{8W} = 1$$

**Ex.15** Two lamps, one rated 100 W at 220 V, and the other 60 W at 220 V, are connected in parallel to the electric mains supply. What current is drawn from the line if the supply voltage is 220 V?

**Sol.** Resistance of first lamp,  $r_1 = \frac{V^2}{P} = \frac{(220)^2}{100} = 484\Omega$

$$\text{resistance of the second lamp, } r_2 = \frac{V^2}{P} = \frac{(220)^2}{60} = 806.7\Omega$$

Since the two lamps are connected in parallel, the equivalent resistance is given by

$$\frac{1}{R_p} = \frac{1}{r_1} + \frac{1}{r_2} = \frac{r_2 + r_1}{r_1 r_2}$$

$$\text{or } R_p = \frac{r_1 r_2}{r_1 + r_2} = \frac{484 \times 806.7}{484 + 806.7} = \frac{390442.8}{1290.7} = 302.5\Omega$$

$$\text{Current drawn from the line, i.e., } I = \frac{V}{R_p} = \frac{220V}{302.5\Omega} = 0.73A$$

**Ex.16** Which uses more energy, a 250 W TV set in 1 h, or a 1200 W toaster in 10 minutes?

**Sol.** Energy used by 250 W TV set in 1 h =  $250W \times 1h = 250Wh$

Energy used by 1200 W toaster in 10 min. (i.e.,  $1/6 h$ ) =  $1200W \times (1/6)h = 200Wh$

Thus, a 250 W TV set uses more power in 1 h than a 1200 W toaster in 10 minutes.

**Ex.17** An electric heater of resistance  $8\Omega$  draws 15 A from the service mains for 2 hour. Calculate the rate at which heat is developed in the heater.

**Sol.** Here,  $I = 15A$ ,  $R = 8\Omega$ ,  $t = 2h$

Rate at which heat is developed, i.e, electric power,  $P = I^2 R = (15)^2 \times 8 = 1800W = 1800J/s$

**Ex.18** Explain the following :

- (a) Why is tungsten used almost exclusively for filament of incandescent lamps?
- (b) Why are the conductors of electric heating devices, such as toasters and electric irons, made of an alloy rather than a pure metal?
- (c) Why is the series arrangement not used for domestic circuits?
- (d) How does the resistance of a wire vary with its cross-sectional area?
- (e) Why are copper and aluminium wires usually employed for electricity transmission.

**Sol.**

- (a) Tungsten has a high melting point ( $3380^\circ C$ ) and becomes incandescent (i.e., emits light at a high temperature) at  $2400K$ .
- (b) The resistivity of an alloy is generally higher than that of pure metals of which it is made of.
- (c) In series arrangement, if any one of the appliances fails or is switched off, all the other appliances stop working because the same current is passing through all the appliances.
- (d) The resistance of a wire ( $R$ ) varies inversely as its cross-sectional area ( $A$ ) as  $R \propto 1/A$ .
- (e) Copper and Aluminium wires possess low resistivity and as such are generally used for electricity transmission.



## NCERT QUESTIONS WITH SOLUTIONS

**Q.1** What does an electric circuit mean ?

**Ans.** An electric circuit is a closed and continuous path consisting of many devices like resistors, electric bulbs, etc. through which an electric current flows.

**Q.2** Define the unit of current.

**Ans.** The 51 unit of current is ampere (A). Current flowing through a conductor Is said to be 1 ampere if 1 coulomb of charge flows through it in 1 second.

**Q.3** Calculate the number of electrons constituting one coulomb of charge.

**Ans.** Number of electrons constituting 1 coulomb is given by,

$$n = \frac{Q}{e}, \text{ where, } Q = 1 \text{ C and } e = \text{charge of a single electron} = 1.6 \times 10^{-19} \text{ C}$$

$$\text{or } n = \frac{1\text{C}}{1.6 \times 10^{-19}\text{C}} = 6.25 \times 10^{18} \text{ electrons.}$$

**Q.4** Name a device that helps to maintain a potential difference across a conductor.

**Ans.** A battery can be used to maintain a potential difference across a conductor.

**Q.5** What is meant by saying that the potential difference between two points is 1 V ?

**Ans.** Potential difference between two points is 1 volt if 1 joule of work is done to carry a charge of 1 coulomb from one point to the other.

**Q.6** How much energy is given to each coulomb of charge passing through a 6V battery?

**Ans.** Work done,  $W = QV$  Where,  $Q = 1\text{C}$ ;  $V = 6\text{V}$   $W = 1\text{C} \times 6\text{V} = 6\text{J}$

**Q.7** On what factors does the resistance of a conductor depend?

**Ans.** The resistance ( $R$ ) of a conductor depends upon

(i) its length ( $\ell$ ):  $R \propto \ell$

(ii) its cross-sectional area ( $A$ ):  $R \propto \frac{1}{A}$

(iii) Nature of material i.e., resistivity ( $\rho$ ) of its material:  $R \propto \rho$

(iv) Temperature: more the temperature, more will be its resistance.

**Q.8** Does current flow more easily through a thick wire or a thin wire of the same material when connected to the same source? Why?

**Ans.** The current flows more easily through a thick wire than through a thin wire. This is because the resistance  $R$  of a thick wire (large area of cross-section) is less than that of a thin wire (small area of cross-section) as  $R \propto \frac{1}{A}$ .

**Q.9** Let the resistance of an electrical component remains constant while the potential difference across the two ends of the component decreases to half its former value. What change will occur in the current through it?

**Ans.** We know that  $I = V/R$ , when potential difference becomes  $V/2$ , and resistance remains constant, then, current becomes  $1/2$  of its former value.



**Q.10** Why are coils of electric toasters and electric irons made of an alloy rather than a pure metal?

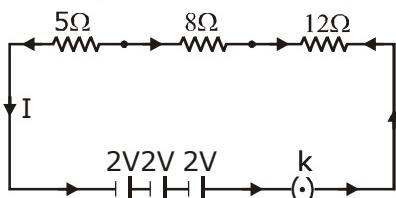
**Ans.** This is because (i) resistivity of an alloy is generally higher than that of pure metals (ii) an alloy has a high melting point and it does not oxidise at high temperatures.

**Q.11** (a) which among iron and mercury is a better conductor? Given,  $\rho_{\text{iron}} = 10.0 \times 10^{-8} \Omega\text{m}$  and  $\rho_{\text{mercury}} = 94.0 \times 10^{-8} \Omega\text{m}$ .

(b) Which material is the best conductor?

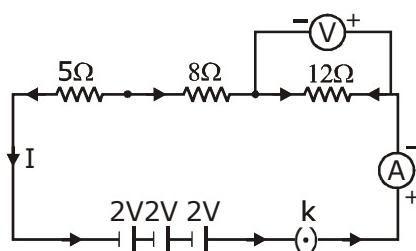
**Ans.** (a) Iron is a better conductor than mercury as resistivity ( $\rho$ ) for iron is less than that for mercury.  
 (b) Silver is the best conductor because its resistivity ( $\rho$ ) is least.

**Q.12** Draw a schematic diagram of a circuit consisting of a battery of three cells of 2V each, a 5 ohm resistor, an 8 ohm resistor, and a 12 ohm resistor, and a plug key, all connected in series.



**Ans.**

**Q.13** Redraw the circuit of Q. 12, putting in an ammeter to measure the current through the resistors and a voltmeter to measure the voltage across the 12 ohm resistor. What would be the reading in the ammeter and the voltmeter?



**Ans.** Since all the three resistances are in series, total resistance in the circuit,

$$R = 5 + 8 + 12 = 25\Omega$$

$$\text{Current in the circuit, } I = \frac{V}{R} = \frac{2+2+2}{25} = \frac{6}{25} = 0.24 \text{ A, thus, ammeter will read 0.24 A.}$$

$$\text{Potential difference across 12 ohm resistor, } V = I \times R = 0.24 \times 12 = 2.88 \text{ V}$$

**Q.14** Judge the equivalent resistance when the following are connected in parallel (a)  $1\Omega$  and  $10^6\Omega$  (b)  $1\Omega$ ,  $10^3\Omega$  and  $10^6\Omega$ .

**Ans.** (a) Approx.  $1\Omega$  (slightly less than  $1\Omega$ ) as other one ( $10^6\Omega$ ) is very large as compared to  $1\Omega$ . In parallel combination of resistors, the equivalent resistance is lesser than the least resistance (in this case,  $1\Omega$ ).  
 (b) Again, resistance is approx.  $1\Omega$  (slightly less than  $1\Omega$ ).

**Q.15** An electric lamp of  $100\Omega$ , a toaster of resistance  $50\Omega$  and a water filter of resistance  $500\Omega$  are connected in parallel to a 220V source. What is the resistance of an electric iron connected to the same source that takes as much current as in three appliances and what is current through it?

**Ans.** Resistance of the electric lamp,  $R_1 = 100\Omega$ ; resistance of toaster,  $R_2 = 50\Omega$ ; resistance of water filter,  $R_3 = 500\Omega$

Since  $R_1$ ,  $R_2$  and  $R_3$  are connected in Parallel, their equivalent resistance ( $R_p$ ) is given by

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{100} + \frac{1}{50} + \frac{1}{500} = \frac{5+10+1}{500} = \frac{16}{500} = \frac{4}{125} \quad R_p = \frac{125}{4}$$



Current through the three appliances, i.e.,

$$I = \frac{V}{R_p} = \frac{220}{(125/4)} = 7.04 \text{ A}$$

Since the electric iron drawing the same current when connected to the same source (220 V), its resistance must be equal to  $R_p$ .

$$\text{Thus, resistance of the electric iron, } \frac{125}{4} = 31.25 \Omega$$

Current through the electric iron,  $I = 7.04 \text{ A}$

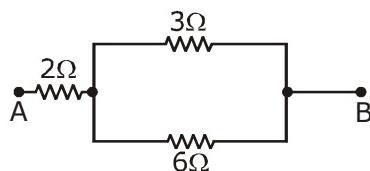
**Q.16** What are the advantages of connecting electrical devices in parallel with the battery instead of connecting them in series.

**Ans.** (a) In case of devices in parallel, if one device gets damaged (or open), all other will work as usual as the whole circuit does not break. This is not so with the devices connected in series because when one device fails, the circuit breaks and all devices stop working.

(b) Since potential difference across all devices is same in parallel circuit, they will draw required current according to their resistances. This is not so in series circuit where same current flows through all the devices, irrespective of their resistances.

**Q.17** How can three resistors of resistances  $2\Omega$ ,  $3\Omega$  and  $6\Omega$  be connected to give a total resistance of (a)  $4\Omega$  (b)  $1\Omega$ ?

**Ans.** (a) To get a total resistance of  $4\Omega$  from resistors of resistance  $2\Omega$ ,  $3\Omega$  and  $6\Omega$ , the resistors are joined as shown below.

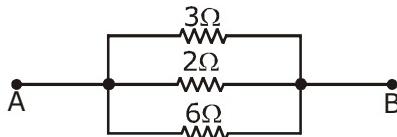


The resistors having resistances  $3\Omega$  and  $6\Omega$  are connected in parallel. This combination is connected in series with the resistor of resistance  $2\Omega$ . Let us check it mathematically, equivalent resistance of  $3\Omega$  and  $6\Omega$  resistors is,

$$R_1 = \frac{3 \times 6}{3 + 6} = \frac{3 \times 6}{9} = 2\Omega$$

Now,  $R_1$  and  $2\Omega$  resistors are in series, their equivalent resistance is  $R_e = R_1 + 2 = 2 + 2 = 4\Omega$ .

(b) To get a resistance of  $1\Omega$  from three given resistors of resistance  $2\Omega$ ,  $3\Omega$ ,  $6\Omega$ , are joined as shown below.



They all are connected in parallel. Their equivalent resistance is given by,

$$\frac{1}{R} = \frac{1}{2} + \frac{1}{3} + \frac{1}{6} = \frac{3+2+1}{6} = \frac{6}{6} = 1 \quad \therefore R = 1\Omega$$



**Q.18** What is (a) the highest, (b) the lowest total resistance that can be secured by combinations of four coils of resistance  $4\Omega$ ,  $8\Omega$ ,  $12\Omega$ ,  $24\Omega$ ?

**Ans.** (a) The highest resistance is secured when all the resistors are connected in series. The equivalent resistance is given by,

$$R_e = 4\Omega + 8\Omega + 12\Omega + 24\Omega = 48\Omega.$$

(b) The lowest resistance is secured when all the four coils are connected in parallel. The equivalent resistance is given by,

$$\frac{1}{R_e} = \frac{1}{4} + \frac{1}{8} + \frac{1}{12} + \frac{1}{24} = \frac{6+3+2+1}{24} = \frac{12}{24} = \frac{1}{2} \quad \text{or } R_e = 2\Omega$$

**Q.19** Why does the cord of electric heater not glow while the heating element does?

**Ans.** The cord of an electric heater is made of thick copper wire and has much lower resistance than the heating element. For the same current ( $I$ ) flowing through the cord and the element, heat produced in the element is much more than that produced in the cord. As a result, the element becomes very hot and glows whereas the cord does not become hot and as such does not glow.

**Q.20** Compute the heat generated while transferring 96000 coulombs of charge in one hour through a potential difference of 50 V.

**Ans.** Here, charge,  $Q = 96000C$ ; time,  $t = 1 \text{ hr}$   
potential difference,  $V = 50V$ .

$$\begin{aligned} \text{Heat produced, } H &= V I t = V \times q \quad [\because q = I t] \\ &= 96000C \times 50V = 4.8 \times 10^6 \text{ J}. \end{aligned}$$

**Q.21** An electric iron of resistance  $20\Omega$  takes a current of 5A. Calculate the heat developed in 30s.

**Ans.** Here, resistance,  $R = 20\Omega$ , current,  $I = 5A$ , time,  $t = 30 \text{ s}$ .  
Heat produced,  $H = I^2 R t = (5)^2 20 \times 30 = 1.5 \times 10^4 \text{ J}$ .

**Q.22** What determines the rate at which energy is delivered by a current?

**Ans.** Electric power determines the rate at which energy is delivered by a current.

**Q.23** An electric motor takes 5A from a 220V. Determine the power and energy consumed in 2Hr.

**Ans.** Here, current,  $I = 5A$ ; potential difference,  $V = 220V$ ; time,  $t = 2\text{hr} = 2 \times 60 \times 60 = 72000$   
 $= 7.92 \times 10^6 \text{ J}$



# ***EXERCISE-I(Board Problems)***

- Q.1** Define resistivity of a material. **[2004]**
- Q.2** A cylinder of a material is 10 cm long and has a cross-section of  $2 \text{ cm}^2$ . If its resistance along the length be  $20\Omega$ , what will be its resistivity in number and units? **[2004]**
- Q.3** Why is tungsten metal selected for making filaments of incandescent lamps ? **[2005]**
- Q.4** A resistance of 10 ohm is bent in the form of a closed circle. What is the effective resistance between the two points at the ends of any diameter of this circle? **[2005]**
- Q.5** A wire of resistance  $5\Omega$  is bent in the form of a closed circle. What is the resistance between two points at the ends of any diameter of the circle ? **[2005]**
- Q.6** A wire of resistance  $20\Omega$  is bent in the form of a closed circle. What is the effective resistance between the two points at the ends of any diameter of the circle? **[2005]**
- Q.7** Why is much less heat generated in long electric cables than in filaments of electric bulbs? **[2005]**
- Q.8** State which has a higher resistance: a 50 W or a 25 W lamp bulb and how many times? **[2005]**
- Q.9** What is the power of torch bulb rated at  $2.5 \text{ V}$  and  $500 \text{ mA}$ ? **[2005]**
- Q.10** There are two electric bulbs, (i) marked  $60 \text{ W}$ ,  $220 \text{ V}$  and (ii) marked  $100 \text{ W}$  ;  $220 \text{ V}$ . Which one of them has higher resistance ? **[2006]**
- Q.11** Out of the two, a toaster of  $1 \text{ kW}$  and an electric heater of  $2 \text{ kW}$ , which has a greater resistance? **[2006]**
- Q.12** What is the SI unit of electrical potential ? **[2007]**
- Q.13** What is meant by the statement "Potential difference between two points A and B in an electric circuit is 1 volt ? **[2007]**
- Q.14** Why is series arrangement not used for connecting domestic electrical appliances in a circuit ? **[2008]**
- Q.15** Out of 60 W and 40 W lamps, which one has a higher resistance when in use? **[2008]**
- Q.16** An electric bulb draws a current of  $0.2 \text{ A}$  when the voltage is 220 volts. Calculate the amount of charge flowing through it in one hour. **[2004]**
- Q.17** An electric iron draws a current of  $0.5 \text{ A}$  when the voltage is 200 volts. Calculate the amount of electric charge flowing through it in one hour. **[2004]**
- Q.18** An electric appliance draws a current of  $0.4 \text{ A}$  when the voltage is 200 volts. Calculate the amount of charge flowing through it in one hour. **[2004]**
- Q.19** Calculate the amount of charge that would flow in 1 hour through the element of an electric bulb drawing a current of  $0.2 \text{ A}$ . **[2004]**
- Q.20** Calculate the amount of charge that would flow in 2 hours through the element of an electric bulb drawing a current of  $0.25 \text{ A}$ . **[2004]**
- Q.21** Calculate the amount of charge that would flow in 1 hour through the element of an electric iron drawing a current of  $0.4 \text{ A}$ . **[2004]**
- Q.22** Derive the relation  $R = R_1 + R_2 + R_3$  when resistors are joined in series. **[2005]**
- Q.23** (i) Draw a circuit diagram to show how two resistors are connected in series. **[2006]**  
(ii) In a circuit if the two resistors of  $5 \Omega$  and  $10 \Omega$  are connected in series, how does the current passing through the two resistors compare ?
- Q.24** A bulb is rated at  $5.0 \text{ V}$ ,  $100 \text{ mA}$ . Calculate its (i) power and (ii) resistance. **[2006]**



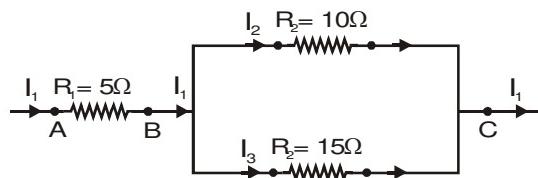
- Q.25** An electric iron has a rating of 750 W, 220 V. Calculate [2007]

- (i) current passing through it, and  
(ii) its resistance, when in use.

- Q.26** An electric lamp is marked 100 W, 220 V. It is used for 5 hours daily. Calculate [2007]

- (i) its resistance while glowing  
(ii) energy consumed in kWh per day.

- Q.27** Three resistors are connected as shown in Fig. Through a resistor of 5 ohm, a current of 1 ampere is flowing. [2003]



- (a) What is the potential difference across AB and across AC ?  
(b) What is the current through the other two resistors ?  
(c) What is the total resistance?

- Q.28** An electric bulb is rated at 200 V-100 W. What is its resistance? Five such bulbs burn for 4 hours. What is electrical energy consumed ? Calculate the cost if the rate is 50 paise unit. [2003]

- Q.29** State the formula co-relating the electric current flowing in a conductor and the voltage applied across it. Also show this relationship by drawing a graph.

What would be the resistance of a conductor if the current flowing through it is 0.35 ampere when the potential difference across it is 1.4 volt. [2004]

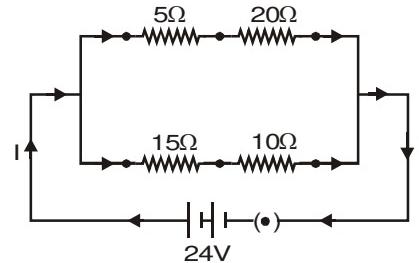
- Q.30** When a potential difference of 1.2 volt is applied across a conductor, the current flowing through it is 0.25 ampere. Calculate the resistance of the conductor. [2004]

- Q.31** (i) State the formula showing how the current  $I$  in a conductor varies when the potential difference  $V$  applied across it is increased stepwise [2004]

- (ii) Show this relationship also on a schematic graph.  
(iii) Calculate the resistance of a conductor if the current flowing through it is 0.2 ampere when the applied potential difference is 0.8 volt.

- Q.32** A torch bulb is rated 5.0 V and 500 mA. Calculate its (i) power (ii) resistance and (iii) energy consumed when it is lighted for 4 hours. [2005]

- Q.33** If a 12 V battery is connected to the arrangement of resistances given in Fig. (with 5 Ω replaced by 10 Ω, 15 Ω replaced by 5 Ω and 10 Ω replaced by 25 Ω). Calculate (i) the total effective resistance of the arrangement and (ii) the total current flowing in the circuit. [2005]



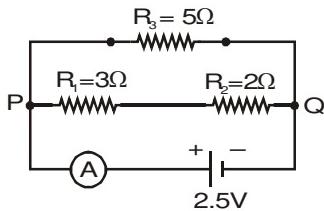
- Q.34** Two electric lamps of 100 W and 25 W respectively are joined in parallel to a supply of 200 V. Calculate the total current flowing through the circuit. [2005]

- Q.35** Two identical resistors, each of resistance 2 Ω, are connected in turn (i) in series, and (ii) in parallel, to a battery of 12 V. Calculate the ratio of power consumed in the two cases. [2005]

- Q.36** Two identical resistors, each of resistance 10 Ω are connected in (i) series, and (ii) in parallel, in turn to a battery of 10 V. Calculate the ratio of power consumed in the combination of resistors in the two cases. [2005]



**Q.37** In the given circuit, calculate (i) total resistance of the circuit, and (ii) current shown by the ammeter. [2005]

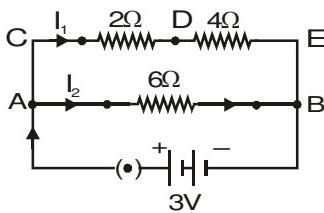


**Q.38** (i) Draw a schematic diagram of a circuit consisting of a battery of five 2 V cells, a  $5\Omega$  resistor, a  $10\Omega$  resistor and a  $15\Omega$  resistor, and a plug key, all connected in series. [2006]

(ii) Calculate the current passing through the above circuit when key is closed.

**Q.39** In a household, 5 tube lights of 40 W each are used for 5 hours and an electric press of 500 W for 4 hour each day. Calculate the total energy consumed by the tube lights and press in a month of 30 days. [2006]

**Q.40** In the circuit shown in Fig., calculate : (a) total resistance in arm CE, (b) total current drawn from the battery, and (c) current in each arm, i.e., AB and CE of the circuit. [2006]



**Q.41** (a) What is meant by 'Electric Resistance' of a conductor? [2007]

(b) A wire of length L and resistance R is stretched so that its length is doubled and area of cross-section is halved. How will its :  
 (i) resistance change ?  
 (ii) resistivity change ?

**Q.42** (a) State Ohm's law. [2007]

(b) Draw a schematic diagram of the circuit for studying Ohm's law.

**Q.43** Two lamps, one rated 60 W at 220 V and the other 40 W at 220 V, are connected in parallel to the electric supply at 220 V. [2008]

(a) Draw a circuit diagram to show the connections.

(b) Calculate the current drawn from the electric supply.

(c) Calculate the total energy consumed by the two lamps together when they operate for one hour.

**Q.44** (a) Distinguish between the terms 'overloading' and 'short-circuiting' as used in domestic circuits. [2008]

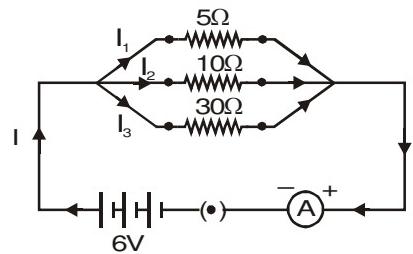
(b) Why are the coils of electric toasters made of an alloy than a pure metal ?

**Q.45** For the circuit shown in Fig., calculate

(a) the value of current through each resistance [2008]

(b) the total current in the circuit

(c) the total effective resistance of the circuit.



**Q.46** (a) Express Ohm's law by a mathematical formula. [2004]

(b) Draw a circuit diagram to verify Ohm's law.

(c) Present the relationship between the voltage applied across a conductor and the current flowing through it graphically.



**Q.47** State Ohm's law. Express it mathematically. Define SI unit of resistance. Derive an expression for the equivalent resistance of three resistors  $R_1$ ,  $R_2$  and  $R_3$  connected in series (or in parallel). **[2004]**

**Q.48** (a) Express Ohm's law both by a mathematical formula and by a graph line. **[2004]**

(b) State SI units of

(i) resistance and

(ii) resistivity.

(c) What will be the equivalent resistance of two resistors  $R_1$  and  $R_2$

(i) connected in series and

(ii) connected in parallel.

**Q.49** (a) What is meant by saying that the potential difference between two points is 1 volt? Name a device that helps to measure the potential difference across a conductor. **[2008]**

(b) Why does the connecting cord of an electric heater not glow hot while the heating element does?

(c) Electrical resistivities of some substances at 20°C are given below:

Silver  $1.60 \times 10^{-8} \Omega \text{ m}$

Copper  $1.62 \times 10^{-8} \Omega \text{ m}$

Tungsten  $5.20 \times 10^{-8} \Omega \text{ m}$

Iron  $10.0 \times 10^{-8} \Omega \text{ m}$

Mercury  $94.0 \times 10^{-8} \Omega \text{ m}$

Nichrome  $100 \times 10^{-6} \Omega \text{ m}$

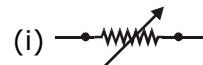
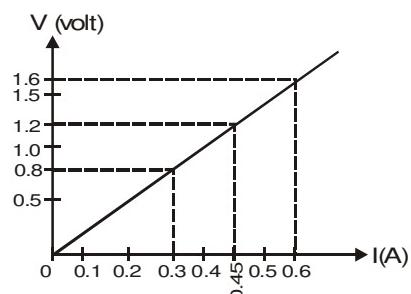
Answer the following questions in relation to them :

(i) Among silver and copper, which one is a better conductor? Why?

(ii) Which material would you advise to be used in electrical heating devices? Why?

**Q.50** (a) Name an instrument that measures electric current in a circuit. Define the unit of electric current. **[2008]**

(b) What do the following symbols mean in circuit diagram?



(c) An electric circuit consisting of a 0.5 m long nichrome wire XY, an ammeter, a voltmeter, four cells of 1.5 V each and a plug key was set up.

(i) Draw a diagram of this electric circuit to study the relation between the potential difference maintained between the points 'X' and 'Y' and the electric current flowing through XY.

(ii) Graph shown in Fig. was plotted between V and I values.

What would be the values of V/I ratios when the potential difference is 0.8 V, 1.2 V and 1.6 V respectively? What conclusion do you draw from these values?



## **EXERCISE-II**

## **SECTION-A**

- Fill in the blanks

1. If we add electrons to a body then the body becomes \_\_\_\_\_.
  2. Current is a \_\_\_\_\_ quantity.
  3. In series circuit the current flowing through each resistor is \_\_\_\_\_ and potential difference across each will be \_\_\_\_\_.
  4. The resistance offered by a cell is called \_\_\_\_\_ of cell.
  5. In a parallel circuit the current resistor is \_\_\_\_\_.

## **SECTION-B**

- **Multiple choice question with one correct answers**



## **SECTION-C**

## • Assertion & Reason

Instructions: In the following questions as Assertion (A) is given followed by a Reason (R). Mark your responses from the following options.

- (A) Both Assertion and Reason are true and Reason is the correct explanation of 'Assertion'
  - (B) Both Assertion and Reason are true and Reason is not the correct explanation of 'Assertion'
  - (C) Assertion is true but Reason is false
  - (D) Assertion is false but Reason is true

1. **Assertion:** Current is a vector quantity  
**Reason:** Current is charge flowing per unit time.
  2. **Assertion:** Current flows from positive to negative terminal of the battery  
**Reason:** This is the conventional direction of current.
  3. **Assertion:** The resistance of a conductor is proportional to the square of its length

**Reason:**  $R = \rho \frac{l}{A}$

4. **Assertion:** Resistivity changes when conductor is stretched or contracted.  
**Reason:** Resistivity is a material property
  5. **Assertion:** Kirchoff's current law states that the net current at a junction is zero.  
**Reason:** This law is based on the conservation of charge principle.



## **SECTION-D**

- Match the following (one to one)

**Column-I** and **column-II** contains **four** entries each. Entries of column-I are to be matched with some entries of column-II. Only One entries of column-I may have the matching with the some entries of column-II and one entry of column-II Only one matching with entries of column-I

- ## **1. Column I**

- (A) Ohms law  
 (B)  $R_{eq} = R_1 + R_2 + \dots + R_n$   
 (C)  $V = E - Ir$   
 (D)  $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_n}$

- ## **Column II**

- (P) Series combination
  - (Q) Terminal potential difference
  - (R)  $V = IR$
  - (S) Parallel combination

## **EXERCISE-III**

## **SECTION-A**

- **Multiple choice question with one correct answers**

1. A 220V–100 W bulb is connected to a supply of 110 V. The power dissipated will be  
(A) 100 W                    (B) 50 W                    (C) 25 W                    (D) 2 W
  2. A wire of resistance R is cut into ten equal parts which are then joined in parallel. The new resistance is  
(A) 0.01 R                    (B) 0.1 R                    (C) 10R                    (D) 100R
  3. A 90 W, 30 V bulb is run on a 120V supply. For this, a wire is connected in series with the bulb. The resistance of the wire is  
(A) 10  $\Omega$                     (B) 20  $\Omega$                     (C) 30  $\Omega$                     (D) 40  $\Omega$
  4. Four wires of equal lengths, each of resistance 5  $\Omega$  are joined to form a square. The equivalent resistance between two diagonally opposite corners of the square is  
(A) 5  $\Omega$                     (B) 10  $\Omega$                     (C) 20  $\Omega$                     (D) 5/4  $\Omega$

SECTION-B

- **Multiple choice question with one or more than one correct answers**

1. The terminal potential difference of a cell of EMF 'E' and internal resistance 'r' is given by the formula  
(A)  $V = E - Ir$       (B)  $V = E$       (C)  $V = 0$       (D)  $V = E + Ir$
  2. The voltage across a conductor is directly proportional to the current flowing across it under constant conditions of  
(A) Pressure      (B) Humidity      (C) Temperature      (D) Density
  3. Choose all correct alternatives  
(A)  $1 \text{ volt} \times 1 \text{ coulomb} = 1 \text{ joule}$       (B)  $1 \text{ volt} \times 1 \text{ ampere} = 1 \text{ J/s}$   
(C)  $1 \text{ volt} \times 1 \text{ watt} = 1 \text{ HP}$   
(D) Watt-hour can be measured in terms of electron-volt

### **SECTION-C**

- **Comprehension**

A battery of EMF 10 V having internal resistance of  $2\Omega$  is connected to an external resistance of  $3\Omega$ . The battery is first in charging mode and then in discharging mode.



## **SECTION-D**

- Match the following (one to many)

**Column-I** and **column-II** contains **four** entries each. Entries of column-I are to be matched with some entries of column-II. One or more than one entries of column-I may have the matching with the some entries of column-II and one entry of column-II may have one or more than one matching with entries of column-I

- ## **1. Column I**

- (A) Ohm's law
  - (B) Heating effect
  - (C) EMF
  - (D) Terminal potential difference

- ## **Column II**

- (P) Nichrome wire
  - (Q) Battery
  - (R)  $V = IR$
  - (S) Ohmic resistance

\* \* \* \*



# EXERCISE-IV(For OLYMPIAD)

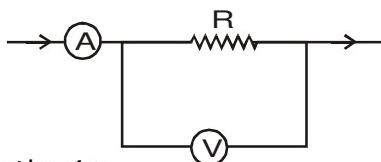
- Q.1** If a charged body attracts another body, the charge on the other body :-  
 (A) must be negative  
 (B) must be positive  
 (C) must be zero  
 (D) may be negative or positive or zero
- Q.2** 1 MeV is equal to :-  
 (A)  $1.6 \times 10^{-19}$  J (B)  $1.6 \times 10^{-14}$  J  
 (C)  $1.6 \times 10^{-13}$  J (D)  $1.6 \times 10^{+13}$  J
- Q.3** A man has five resistors each of value  $\frac{1}{5} \Omega$ . What is the maximum resistance he can obtain by connecting them ?  
 (A)  $1\Omega$  (B)  $5\Omega$   
 (C)  $\frac{1}{2}\Omega$  (D)  $\frac{2}{5}\Omega$
- Q.4** Materials which allow larger currents to flow through them are called :-  
 (A) Insulators (B) Conductors  
 (C) Semiconductors (D) Alloys
- Q.5** If I is the current through a wire and e is the charge of electrons, then the number of electrons in t seconds will be given by :-  
 (A)  $\frac{Ie}{t}$  (B)  $Ite$   
 (C)  $e/It$  (D)  $It/e$
- Q.6** Conventionally, the direction of the current is taken as -  
 (A) the direction of flow to negative charge  
 (B) the direction of flow of atoms  
 (C) the direction of flow of molecules  
 (D) the direction of flow of positive charge
- Q.7** The unit of specific resistance is :-  
 (A) ohm (B) mho  
 (C) ohm-metre (d) ohm per metre
- Q.8** 1 volt equals :-  
 (A) 1 joule  
 (B) 1 joule per coulomb  
 (C) 1 coulomb per metre  
 (D) 1 newton per coulomb
- Q.9** The reciprocal of resistance is conductance. If the unit of resistance is ohm, the unit of conductance will be -  
 (A) ohm (B) volt  
 (C) mho (D) ohm metre $^{-1}$
- Q.10** Good conductors have many loosely bound-  
 (A) atoms (B) molecules  
 (C) protons (D) electrons
- Q.11** One ampere equals :-  
 (A)  $10^6 \mu\text{A}$  (B)  $10^{-6} \mu\text{A}$   
 (C)  $10^{-3} \mu\text{A}$  (D)  $10 \text{ A}$
- Q.12** How many electrons constitute a current of one microampere?  
 (A)  $6.25 \times 10^6$  (B)  $6.25 \times 10^{12}$   
 (C)  $6.25 \times 10^9$  (D)  $6.25 \times 10^{15}$
- Q.13** The SI unit of specific resistance is :-  
 (A) ohm m (B) ohm m $^{-1}$   
 (C) ohm m $^2$  (D) (ohm) $^{-1}$
- Q.14** The effective resistance of a circuit containing resistances in parallel is -  
 (A) equal to the sum of the individual resistances  
 (B) smaller than any of the individual resistances  
 (C) greater than any of the individual resistances  
 (D) sometimes greater and sometimes smaller than the individual resistances
- Q.15** Electric field intensity is  
 (A) a scalar quantity  
 (B) a vector quantity  
 (C) neither scalar nor vector  
 (D) sometimes scalar and sometimes vector
- Q.16** Electric potential is  
 (A) A scalar quantity  
 (B) a vector quantity  
 (C) neither scalar nor vector  
 (D) sometimes scalar and sometimes vector
- Q.17** In Coulomb's law, the constant of proportionality k has the units -  
 (A) N (B) Nm $^2$   
 (C) NC $^2/m^2$  (D) Nm $^2/C^2$
- Q.18** The variable resistance is called :-  
 (A) resistor (B) rheostat  
 (C) open switch (D) none of these
- Q.19** The law that governs the force between electric charges is called -  
 (A) Ampere's law (B) Coulomb's law  
 (C) Faraday's law (D) Ohm's law



- Q.20** A charge  $q$  is placed at the center of the line joining two equal charges  $Q$ . The system of the three charges will be in equilibrium, if  $q$  is equal to -
- (A)  $-\frac{Q}{2}$       (B)  $-\frac{Q}{4}$   
 (C)  $+\frac{Q}{4}$       (D)  $+\frac{Q}{2}$
- Q.21** The force between two electrons separated by a distance  $r$  varies as :-
- (A)  $r^2$       (B)  $r$   
 (C)  $r^{-1}$       (D)  $r^{-2}$
- Q.22** When the distance between the charged particles is halved, the force between them becomes -
- (A) One-fourth      (B) Half  
 (C) Double      (D) Four times
- Q.23** A charge  $q_1$  exerts some force on a second charge  $q_2$ . If third charge  $q_3$  is brought near, the force of  $q_1$  exerted on,  $q_2$  :-
- (A) Decreases  
 (B) Increases  
 (C) Remains unchanged  
 (D) Increases if  $q_3$  is of the same sign as  $q_1$  and decreases if  $q_3$  is of opposite sign
- Q.24** If the charge is moved against the coulomb force of an electric field -
- (A) Work is done by the electric field  
 (B) Energy is used from some outside force  
 (C) The strength of the field is decreased  
 (D) The energy of the system is decreased
- Q.25** The ratio of the forces between two small spheres with constant charge (a) in air (b) in a medium of dielectric constant  $K$  is-
- (A)  $1 : K$       (B)  $K : 1$   
 (C)  $1 : K^2$       (D)  $K^2 : 1$
- Q.26** Two charges are placed at a distance. If a glass slab is placed between them, force between them will be
- (A) Zero      (B) Increased  
 (C) Decreased      (D) Remains same
- Q.27** If a unit positive charge is taken from one point to another over an equipotential surface, then -
- (A) Work is done on the charge  
 (B) Work is done by the charge  
 (C) Work done is constant  
 (D) No work is done
- Q.28** If a glass rod is rubbed with silk, it acquires a positive charge because-
- (A) Protons are added to it  
 (C) Electrons are added to it  
 (B) Protons are removed from it  
 (D) Electrons are removed from it
- Q.29** Two resistors of resistance  $R_1$  and  $R_2$  having  $R_1 > R_2$  are connected in parallel. For equivalent resistance  $R$ , the correct statement is -
- (A)  $R > R_1 + R_2$   
 (B)  $R_1 < R < R_2$   
 (C)  $R_2 < R < (R_1 + R_2)$   
 (D)  $R < R_1$
- Q.30** Two unequal resistances are connected in parallel. Which one of the statement is correct-
- (A) The current flowing is same in both  
 (B) More current will flow from higher resistance piece  
 (C) The potential drop is same in both  
 (D) The conductivity of lower resistance is less
- Q.31** There are 8 equal resistances  $R$ . Two are connected in parallel, such four groups are connected in series, the total resistance
- (A)  $R/2$       (B)  $2R$   
 (C)  $4R$       (D)  $8R$
- Q.32** In a conductor 4 coulombs of charge flows for 2 seconds. The value of electric current will be-
- (A) 4V      (B) 4A  
 (C) 2A      (D) 2V
- Q.33** In a conductor, the flow of current is :-
- (A) Flow of molecules  
 (B) Flow of free electrons  
 (C) Flow of positive charge  
 (D) Flow of ions
- Q.34** Three resistances of magnitude 2, 3 and 5 ohm are connected in parallel to a battery of 10 volts and of negligible resistance. The potential difference across  $3\Omega$  resistance will be-
- (A) 2V      (B) 3V  
 (C) 5V      (D) 10V

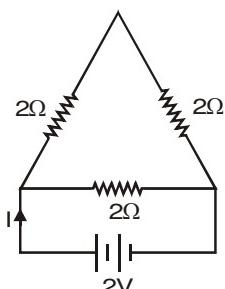


**Q.35** In the circuit shown below, the ammeter A reads 5A and the voltmeter V reads 20 V (Fig.). The correct value of resistance R is:-



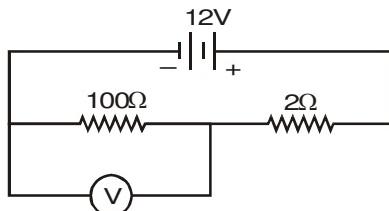
- (A) exactly  $4\Omega$
- (B) slightly greater than  $4\Omega$
- (C) slightly less than  $4\Omega$
- (D) zero

**Q.36** What is the current in the circuit shown (Fig.)



- (A) 1.5 A
- (B) 0.5 A
- (C) 2.5 A
- (D) none of these

**Q.37** In the circuit shown in Fig., the reading of the voltmeter V will be :-

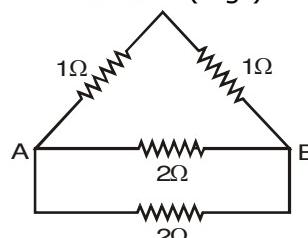


- (A) 4V
- (B) 2V
- (C) 6V
- (D) 3V

**Q.38** Which of the following networks yields maximum effective resistance between A and B?

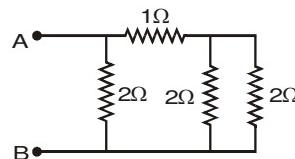
- (A)
- (B)
- (C)
- (D)

**Q.39** What is the resistance between A and B in the given network (Fig.) ?



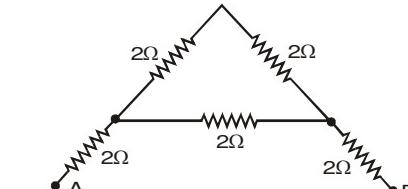
- (A)  $2\Omega$
- (B)  $2\Omega$
- (C)  $\frac{3}{2}\Omega$
- (D)  $\frac{2}{3}\Omega$

**Q.40** The equivalent resistance between A and B (Fig.) will be :-



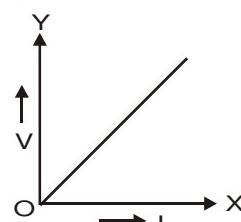
- (A)  $7\Omega$
- (B)  $2\Omega$
- (C)  $\frac{5}{3}\Omega$
- (D)  $1\Omega$

**Q.41** What is the resistance between A and B ?



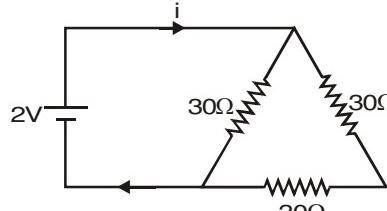
- (A)  $\frac{3}{4}\Omega$
- (B)  $\frac{4}{3}\Omega$
- (C)  $\frac{16}{3}\Omega$
- (D) infinity

**Q.42** The slope of voltage (V) versus current (I) is called :-



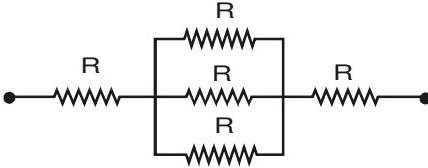
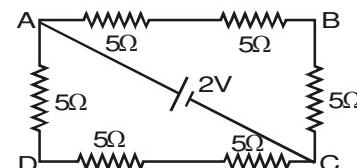
- (A) resistance
- (B) conductance
- (C) resistivity
- (D) conductivity

**Q.43** The current in the adjoining circuit will be-



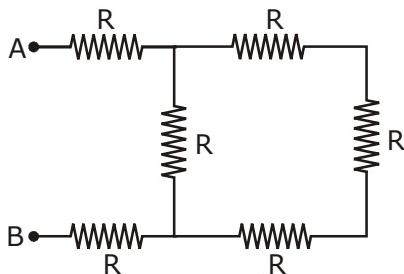
- (A)  $\frac{1}{45}A$
- (B)  $\frac{1}{15}A$
- (C)  $\frac{1}{10}A$
- (D)  $\frac{1}{5}A$



- Q.44** The resistance wires are made of the material having :-  
 (A) Low specific resistance and low temperature coefficient of resistance.  
 (B) High specific resistance and low temperature coefficient of resistance.  
 (C) Low specific resistance and high temperature coefficient of resistance.  
 (D) High specific resistance and high temperature coefficient of resistance.
- Q.45** The resistance between points A and B in Fig. is :-
- 
- (A)  $\frac{7}{3}R$       (B)  $3R$   
 (C)  $5R$       (D)  $\frac{4}{3}R$
- Q.46** Two wires of same material and same mass have their lengths in the ratio 1 : 2. Their electrical resistances are in the ratio  
 (A) 1 : 1      (B) 1 : 2  
 (C) 2 : 1      (D) 1 : 4
- Q.47** A 24 V potential difference is applied across a parallel combination of four 6-ohm resistors. The current in each resistor is  
 (A) 1A      (B) 4A  
 (C) 16 A      (D) 36 A
- Q.48** Three resistors in parallel have an effective resistance of 1 ohm. When they are connected in series their resistance is 9 ohm. The resistance of each resistor is :  
 (A) 4, 4, 1 ohm      (B) 6, 2, 1 ohm  
 (C) 3, 3, 3 ohm      (D) 2, 3, 4 ohm
- Q.49** Four 20 ohm resistors are connected together to form a square. The resistance between opposite corners will be :-  
 (A) 20 ohm      (B) 22 ohm  
 (C) 24 ohm      (D) 24.8 ohm
- Q.50** The cost of electricity is about 30 paise per unit for household use. This unit is the same as  
 (A) ohm      (B) ampere  
 (C) volt      (D) kilowatt-hour
- Q.51** A fuse wire should have  
 (A) low resistance and low melting point  
 (B) low resistance and high melting point.  
 (C) high resistance and low melting point.  
 (D) high resistance and high melting point.
- Q.52** A one-ohm and half-ohm resistor are connected in parallel across a 3 volt battery. Total energy given out per second is  
 (A) 27 J      (B) 9 J  
 (C) 4.5 J      (D) 3 J
- Q.53** Two electric lamps each of 100 watts 220 V are connected in series to a supply of 220 volts. The power consumed would be  
 (A) 100 watts      (B) 200 watts  
 (C) 25 watts      (D) 50 watts
- Q.54** A rheostat can be used in an electrical circuit as a  
 (A) standard resistance  
 (B) potential divider  
 (C) heat controller  
 (D) on-off switch
- Q.55** The potential difference between points A and B of adjoining figure is
- 
- (A)  $\frac{2}{3}V$       (B)  $\frac{8}{9}V$   
 (C)  $\frac{4}{3}V$       (D) 2 V

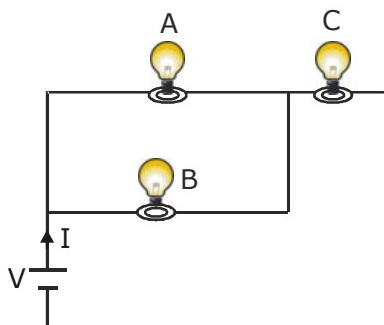


**Q.56** the value of equivalent resistance between the points A and B in the given circuit, will be [NTSE]



- (A)  $6R$       (B)  $\frac{4R}{11}$   
 (C)  $\frac{11R}{4}$       (D)  $\frac{R}{6}$

**Q.57** Consider a simple circuit containing a battery and three identical incandescent bulbs A, B and C. Bulb A is wired in parallel with bulb B and this combination is wired in series with bulb C. What would happen to the brightness of the other two bulbs if bulb A were to burn out? [NTSE]



- (A) Only bulb B would get brighter  
 (B) Both A and B would get brighter  
 (C) Bulb B would get brighter and bulb C would get dimmer  
 (D) There would be no change in the brightness of either bulb B or bulb C.

**Q.58** Three equal resistors connected in series across a source of emf dissipates 10 watts of power. What will be the power dissipated in watts if the same resistors are connected in parallel across the same source of emf?

- (A) 10W      (B) 30W      [NTSE]  
 (C) 90W      (D)  $\frac{10}{3}W$

**Q.59** Eight identical spherical mercury drops charged to a potential of 20V each are coalesced into a single spherical drop

[NTSE]

- (A) the internal energy of the system remains the same  
 (B) the new potential of the drop is 80V  
 (C) internal energy of the system decreases  
 (D) the potential remains the same i.e. 20V

**Q.60** A technician has 10 resistors each of resistance  $0.1\Omega$ . The largest and smallest resistance that he can obtain by combining these resistors are [NTSE]

- (A)  $10\Omega$  and  $1\Omega$  respectively  
 (B)  $1\Omega$  and  $0.1\Omega$  respectively  
 (C)  $1\Omega$  and  $0.01\Omega$  respectively  
 (D)  $0.1\Omega$  and  $0.01\Omega$  respectively



# Answers

**EXERCISE-II****SECTION-A**

- |                    |                        |
|--------------------|------------------------|
| 1. Negatively      | 2. Scalar              |
| 3. Same, different | 4. Internal resistance |
| 5. different       |                        |

**SECTION-B**

- |        |        |        |        |
|--------|--------|--------|--------|
| 1. (C) | 2. (B) | 3. (D) | 4. (B) |
|--------|--------|--------|--------|

**SECTION-C**

- |        |        |        |        |        |
|--------|--------|--------|--------|--------|
| 1. (D) | 2. (A) | 3. (D) | 4. (D) | 5. (A) |
|--------|--------|--------|--------|--------|

**SECTION-D**

- |                                       |
|---------------------------------------|
| 1. (A)-(R), (B)-(P), (C)-(Q), (D)-(S) |
|---------------------------------------|

**EXERCISE-III****SECTION-A**

- |        |        |        |        |
|--------|--------|--------|--------|
| 1. (C) | 2. (B) | 3. (C) | 4. (A) |
|--------|--------|--------|--------|

**SECTION-B**

- |          |          |          |
|----------|----------|----------|
| 1. (A,D) | 2. (A,C) | 3. (A,D) |
|----------|----------|----------|

**SECTION-C**

- |        |        |        |
|--------|--------|--------|
| 1. (C) | 2. (A) | 3. (C) |
|--------|--------|--------|

**SECTION-D**

- |   |
|---|
| 1. (A)-(R,S), (B)-(P), (C)-(Q), (D)-(R,S) |
|---|

**EXERCISE-IV**

- |     |   |     |   |     |   |     |   |     |   |     |   |     |   |
|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|
| 1.  | D | 2.  | C | 3.  | A | 4.  | B | 5.  | D | 6.  | D | 7.  | C |
| 8.  | B | 9.  | C | 10. | D | 11. | A | 12. | B | 13. | A | 14. | B |
| 15. | B | 16. | A | 17. | D | 18. | B | 19. | B | 20. | B | 21. | D |
| 22. | D | 23. | C | 24. | B | 25. | B | 26. | D | 27. | D | 28. | D |
| 29. | D | 30. | C | 31. | B | 32. | C | 33. | B | 34. | D | 35. | B |
| 36. | A | 37. | A | 38. | A | 39. | D | 40. | D | 41. | C | 42. | A |
| 43. | C | 44. | B | 45. | A | 46. | D | 47. | B | 48. | C | 49. | A |
| 50. | D | 51. | A | 52. | A | 53. | D | 54. | B | 55. | C | 56. | C |
| 57. | C | 58. | C | 59. | B | 60. | C |     |   |     |   |     |   |



## MAGNETIC EFFECTS OF ELECTRIC CURRENT

### MAGNETISM

Magnet was first discovered some 5,000 years ago in Magnesia. It could attract small pieces of iron towards it and had directional property i.e. when suspended freely, it always points in north-south direction. There is a true story behind its discovery.

**(A) Discovery of Magnet:** There was a shepherd boy named Magnaus in the town Magnesia in Greece. He had wooden stuff attached to iron sole. One day he left it in a mine. When he came back, the iron sole was firmly attached to the roof. He got terrified and thought it to be work of some evil spirit or ghost. The roof was actually an iron ore ( $Fe_3O_4$ ) magnetite. This first discovered magnet was called magnetite or natural magnet. It points in a particular (N-S) direction. It is also called loading stone which has now been changed to lode stone.

Gilbert made detailed study of magnets and their properties. Magnets are essential parts of all generators used for the production of electricity. They also form essential parts of electric motors, TV., radio, stereos and large number of instruments.

**(B) Properties of Magnets**

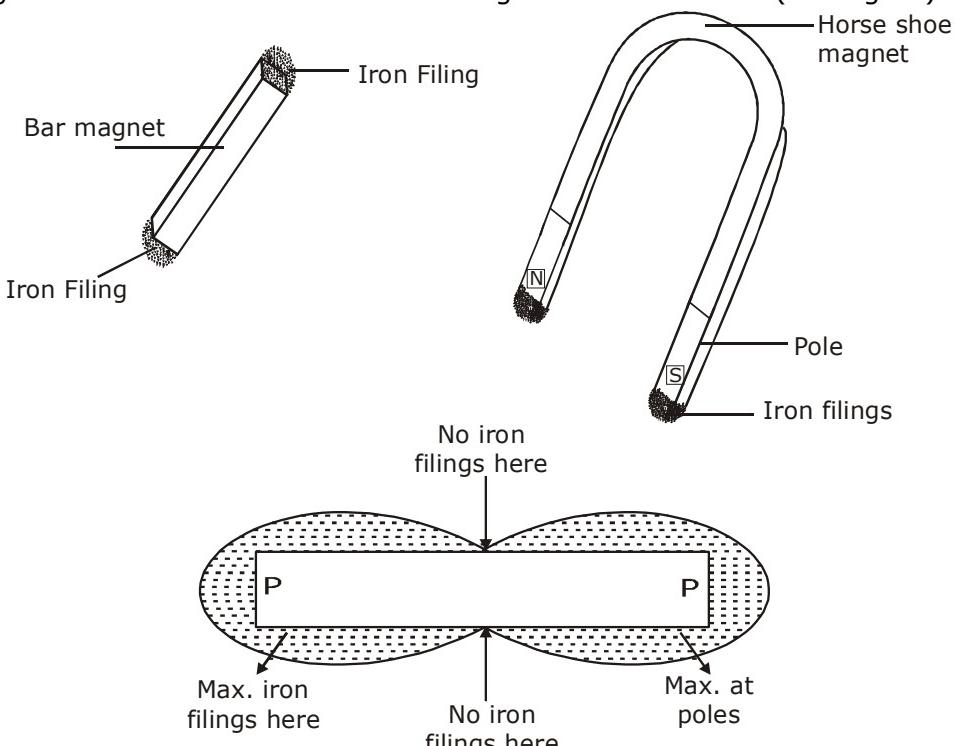
- (i) It attracts small pieces of iron towards it i.e. it has attractive property.
- (ii) When suspended freely, it always points in north south direction. Thus magnet possesses directional property.

**(C) Properties of magnet:** William Gilbert of England was the first person to study and record the properties of a magnet in a book titled "The magnet". Let us study some important properties of magnets.

**(D) Poles of Magnet:** The two ends of a magnet where the magnetic force is greatest are called the poles of the magnet. Each magnet has two poles magnetic north pole and magnetic south pole.

### ACTIVITY

Spread out some iron filings over a sheet of paper. Now, move a bar magnet over the filings taking care that all parts of the magnet move through iron filings and Observe how the iron filings are distributed all over the magnet. You will notice that most of the iron filings cling near the ends of the magnet while there are a few iron filings near the middle (see figure).



Repeat the experiment with a horse-shoe magnet You will find that all magnets have maximum attractive power at their poles. This activity shows another fact about the attractive property of magnets.



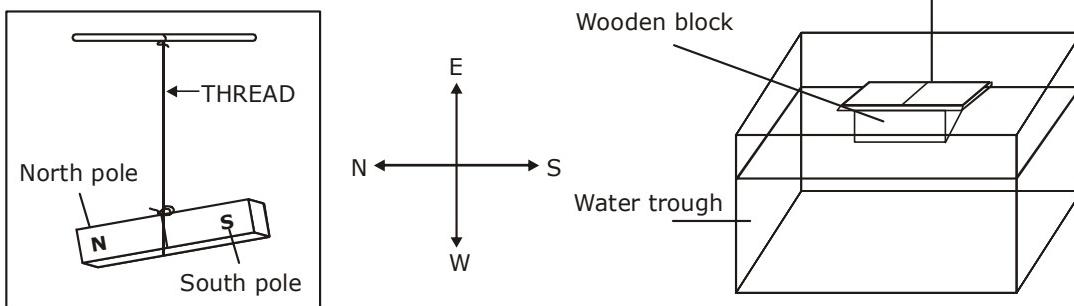
## MAGNETIC EFFECTS OF ELECTRIC CURRENT

- (E) Directional Property:** The end of the magnet that points towards the North is called the North Pole (N-Pole) and the other end of the magnet pointing towards the South is called the South Pole (S-Pole), A magnet always points in the north-south direction when suspended freely.

### ACTIVITY

Take a bar magnet and suspend it freely as shown in figure or float it on a block of wood in water. The magnet comes to rest after sometime. Disturb it a little from its position of rest and see what happens. You will find that the magnet always comes to rest in the north-south direction.

Bar magnet

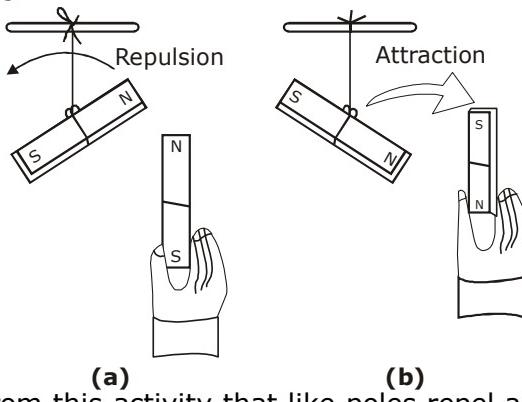


- (F) Like poles repel each other:**

### ACTIVITY

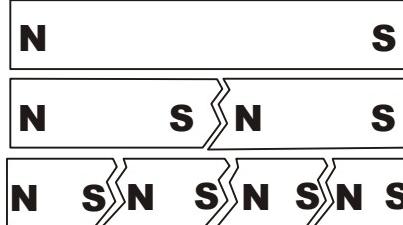
Take two bar magnets. Suspend one magnet with a piece of thread. it will come to rest in the north-south direction. Hold the other magnet in your hand and bring its north pole near the north pole of the suspended magnet, as shown in figure. What do you see? You will find that the north pole of the suspended magnet is repelled, i.e., north pole moves away.

Now bring the south pole of the magnet in the hand near the north pole of the suspended magnet (see figure) You will find that the north pole of the suspended magnet will be attracted towards the south pole of the other magnet, i.e., north pole of the suspended magnet will come close to the south pole of the magnet in hand.



We, therefore, conclude from this activity that like poles repel and unlike poles attract each other.

- (G) Magnetic poles always exist in pairs:** If a bar magnet broken into two pieces you will see that each piece behaves as a whole magnet. This shows that new poles are formed at the broken ends as shown in the figure. If these pieces are broken again, each smaller piece still remains a whole magnet with two opposite poles. Even a very small piece of a magnet is a whole magnet. Thus, we see that even the smallest piece of a magnet has north and south poles and we cannot separate the two poles.



We, therefore, conclude that the poles of a magnet cannot be separated. Magnetic poles always exist in pairs.



## MAGNETIC FIELD LINES

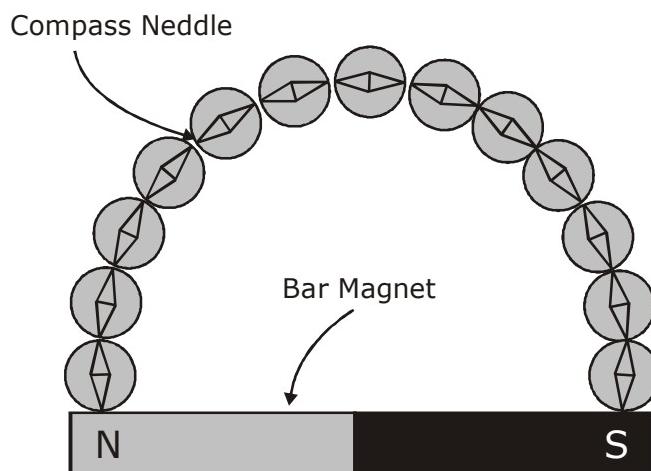
Magnetic field line is an imaginary line such that tangent to it at any point gives the direction of magnetic field at that point in space. Magnetic field lines are drawn to represent magnetic field. Magnetic field lines can be drawn with the help of magnetic compass. Magnetic field lines are also called as magnetic lines of force.

### **Properties of Magnetic field lines:**

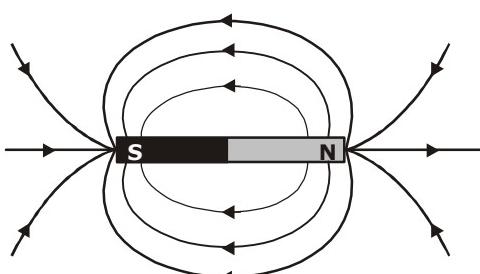
- (i) Magnetic field lines are close curves that start from north pole and end on south pole outside magnet. Inside magnet the field lines start from south pole and end on north pole.
- (ii) No two magnetic field lines ever intersect because if it is so, there will be two directions of magnetic field at that point which is not possible.
- (iii) Magnetic field lines come closer to one another near the pole of a magnet but they are widely separated at other places.

### **Plotting magnetic field lines of a magnet:**

To trace the magnetic field lines, place the bar magnet NS on a sheet of paper and mark its boundary. Mark a point A near the north pole of the given magnet. Place the compass needle (Figure) such that one of its ends (south) lies exactly over point A . Mark point B on the paper at the opposite (north) end of the compass needle. Move the compass needle so that the south end of the compass needle lies over B and mark point C at the north end of the needle and so on. Go on doing so till a point is reached near the south pole of the given magnet. Join all these points with a free hand curve so as to form a smooth dotted curve.



Mark an arrow head to show the direction of magnetic field line, which will be north pole to south pole outside the magnet. This dotted curve marked with an arrow head represents a magnetic field line. Similarly starting from other points near the north pole of the magnet, draw other magnetic field lines. Magnetic field lines plotted for a bar magnet are as shown in figure.



We can visualise the magnetic field around a bar magnet by sprinkling some iron filings near a bar magnet and tapping the sheet on which the magnet is placed. The iron filings will orient themselves according to figure.



**Newton's Thought**

North pole of a bar magnet is placed near an iron bar. (a) If the iron bar is attracted towards the north pole of the bar magnet, does it mean that iron bar is a magnet? (b) If the iron bar is repelled by the north pole of the bar magnet, does it mean that iron bar is a magnet?

**Explanation**

- (a) No, the iron bar may or not be a magnet. This is because an unmagnetised iron bar is also attracted towards a bar magnet.
- (b) Yes, the iron bar is a magnet. This is because only like poles of two magnets repel; a magnet and an unmagnetised iron can never repel each other. Here, we can say that 'true test of magnetisation on materials is the repulsion not the attraction'.

**MAGNETIC FIELD OF EARTH**

A freely suspended magnet always points in the north south direction even in the absence of any other magnet. This suggests that the earth itself behaves as a magnet which causes a freely suspended magnet or magnetic needle to point always in particular direction; north and south. The shape of the earth's magnetic field resembles that of an imaginary bar magnet.

The axis of earth magnetic field is inclined at an angle of about  $15^\circ$  with the geographical axis. Due to this a freely suspended magnet (or magnetic needle) makes an angle of about  $15^\circ$  with the geographical axis and points only approximately in the north south directions at a place.

**MAGNETIC EFFECT OF CURRENT (or Electromagnetism) :**

The magnetic effect of current was discovered by Oersted in 1820. Oersted found that a wire carrying a current was able to deflect a compass needle. Now, the compass needle is a tiny magnet, which can be deflected only by a magnetic field. Since a current carrying wire was able to deflect a compass needle, it was concluded that a current flowing in a wire always gives rise to a magnetic field around it. The importance of magnetic field of current lies in the fact that gives rise to mechanical forces.

**(i) Magnetic field patterns produced by current carrying conductors having different shapes:**

The pattern of magnetic field (or shape of magnetic field lines) produced by a current carrying conductor depends on its shape.

Different magnetic field patterns are produced by current carrying conductors having different shapes.

- (A) A straight conductor (or straight wire) carrying current.  
(B) A circular loop (or circular wire) carrying current.  
(C) A solenoid (long coil of wire) carrying current.

**(A) Magnetic field pattern due to straight current carrying conductor (Straight current carrying wire):**

**The magnetic field lines around a straight conductor (straight line) carrying current are concentric circles whose centres lie on the wire. The magnetic field lines are circular in nature.**

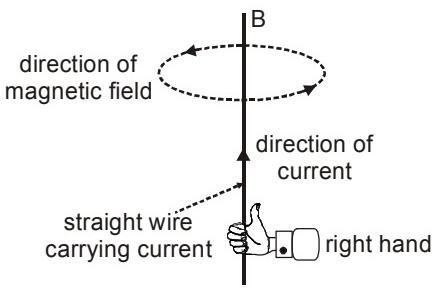
The magnitude of magnetic field produced by a straight current carrying wire at a given point is:

- (a) directly proportional to the current passing in the wire.  
(b) inversely proportional to the distance of that point from the wire.

**Direction of Magnetic Field Produced by current carrying conductor :****(a) According to Maxwell's right hand thumb rule:**

Imagine that you are grasping (or holding) the current carrying wire in your right hand so that your thumb points in the direction of current, then the direction in which your fingers encircle the wire will give the direction of magnetic field lines around the wire.





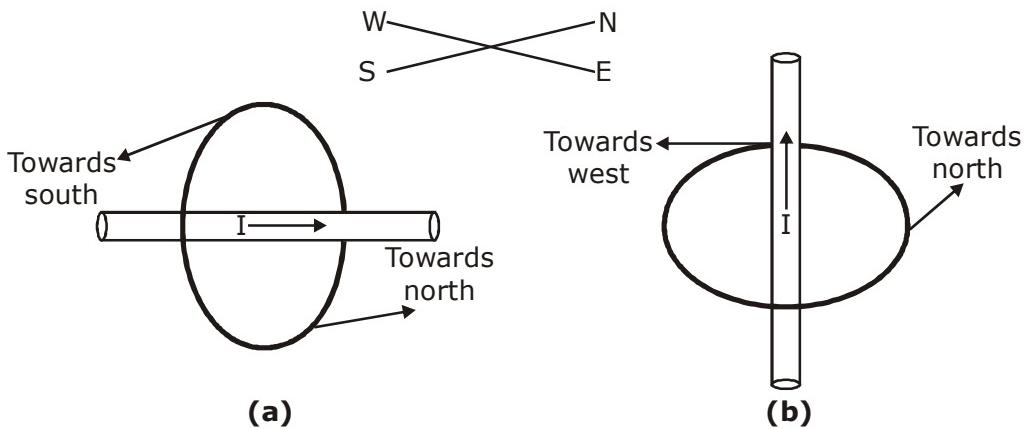
Maxwell's right hand thumb rule is also known as Maxwell's corkscrew rule (Corkscrew is a device for pulling corks from bottles, and consists of a spiral metal rod and a handle).

#### Newton's Thought

- (a) A current through a horizontal power line flows in west to east direction. What is the direction of magnetic field at a point directly below it and at a point directly above it?
- (b) A vertical wire carries an electric current in upward direction. What is the direction of magnetic field at point to the north of it and a point to the east of it?

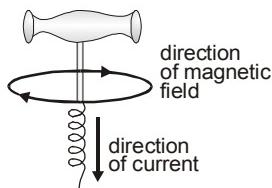
#### Explanation

- (a) The current is in the west-east direction [see figure (a)]. Applying the right-hand thumb rule, we get that the direction of magnetic field at a point above the wire is from north to south (towards south). The direction of magnetic field at a point directly below the wire is from south to north (towards north).
- (b) The current is in the vertically upward direction [see figure (b)]. Applying the right-hand thumb rule, we get that the direction of magnetic field at a point to the north of it is east to west (towards west). The direction of magnetic field at a point to the east of the wire is from south to north (towards north).

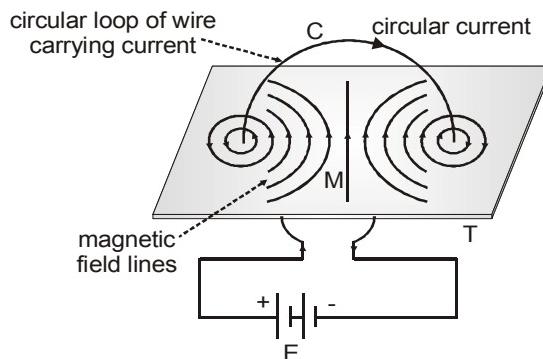


#### (b) According to Maxwell's corkscrew rule :

Imagine driving a corkscrew in the direction of current, then the direction in which we turn its handle is the direction of magnetic field (or magnetic field lines).



**(B) Magnetic field pattern due to a circular loop (or circular wire) Carrying current :**



When current is passed through a straight wire, a magnetic field is produced around it. It has been found that the magnetic effect of current increases if instead of using a straight wire, the wire is converted into a circular loop. When a current is passed through the circular loop of wire, a magnetic field is produced around it.

**The magnitude of magnetic field produced by a current carrying circular loop (or circular wire) at its centre is :**

- (i) Directly proportional to the current passing through the circular loop (or circular wire), and
- (ii) Inversely proportional to the radius of circular loop (or circular wire).

The strength of magnetic field produced by a circular coil carrying current is directly proportional to both, **number of turns (n), and current (I)** ; **but inversely proportional to its radius (r)**.

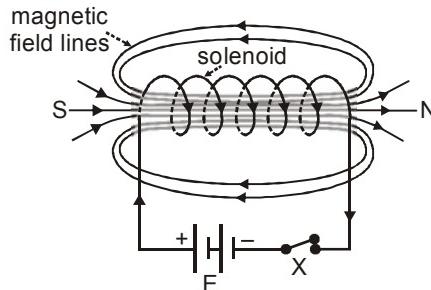
The strength of magnetic field produced by a current carrying circular coil can be increased -

- (i) by increasing the number of turns of wire in the coil
- (ii) by increasing the current flowing through the coil and,
- (iii) by decreasing the radius of the coil.

**(C) Magnetic field due to a solenoid :**

The solenoid is a long coil containing a large number of close turns of insulated copper wire.

The magnetic field produced by a current carrying solenoid is similar to the magnetic field produced by a bar magnet.



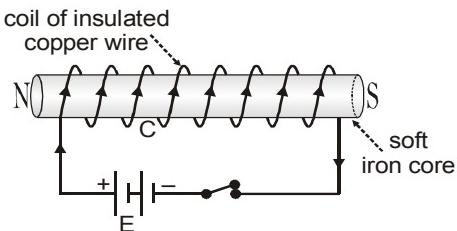
The strength of magnetic field produced by a current carrying solenoid depends on :

- (i) The number of turns in the solenoid :** Larger the number of turns in the solenoid greater will be the magnetism produced.
- (ii) The strength of current in the solenoid :** Larger the current passed through solenoid, stronger will be the magnetic field produced.
- (iii) The nature of core material used in making solenoid :** The use of soft iron rod as core in a solenoid produces the strongest magnetism.



## ELECTROMAGNET

An electric current can be used for making temporary magnet known as electromagnets. An electromagnet works on the magnetic effect of current. An electromagnet consists of a long coil of insulated copper wire wound on a soft iron core.



When the two ends of the copper coil are connected to a battery, an electromagnet is formed. The core of an electromagnet must be of soft iron because soft iron loses all of its magnetism when current in the coil is switched off. If steel is used for making the core of an electromagnet, the steel does not lose all its magnetism when the current is stopped and it becomes a permanent magnet so steel is not used for making electromagnets.

**(a) Factors Affecting the Strength of an Electromagnet :**

- (i) The number of turns in the coil :** If we increase the number of turns in the coil, the strength of electromagnet increases.
- (ii) The current flowing in the coil :** If the current in the coil is increased, the strength of electromagnet increases.
- (iii) The length of air gap between its poles :** If we reduce the length of air gap between the poles of an electromagnet, then its strength increases.

## MAGNETISM IN HUMAN BEINGS

Extremely weak electric currents are produced in the human body by the movement of charged particles called ions. These are called ionic currents. When the weak ionic currents flow along the nerve cells, they produce magnetic field in our body. The two main organs of the human body where the magnetic field produced is quite significant are the heart and the brain.

The magnetism produced inside the human body (by the flow of ionic currents) forms the basis of a technique called **Magnetic Resonance Imaging (MRI)** which is used to obtain images (or pictures) of the internal parts of our body.

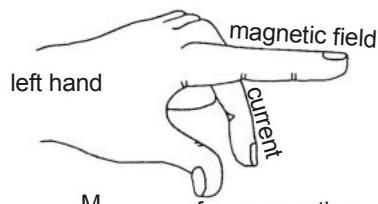
<b>Bar magnet (or Permanent magnet)</b>		<b>Electromagnet</b>	
1	The bar magnet is a permanent magnet.	1	An electromagnet is a temporary magnet. Its magnetism is only for the duration of current passing through it. So, the magnetism of an electromagnet can be switched on or switched off as desired.
2	A permanent magnet produces a comparatively weak force of attraction	2	An electromagnet can produce very strong magnetic force.
3	The strength of a permanent magnet cannot be changed.	3	The strength of an electromagnet can be changed by changing the number of turns in its coil or by changing the current passing through it.
4	The (north-south) polarity of a permanent magnet is fixed and cannot be changed.	4	The polarity of an electromagnet can be changed by changing the direction of current in its coil.



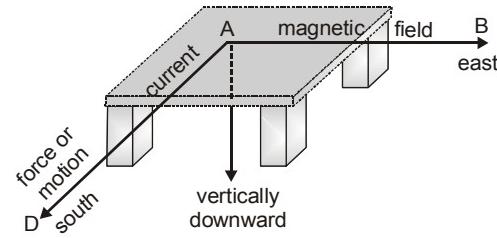
## FLEMING'S LEFT HAND RULE FOR THE DIRECTION OF FORCE

### According to Fleming's left hand rule :

Hold the forefinger the centre finger and the thumb of your left hand at right angles to one another. Adjust your hand in such a way that the forefinger points in the direction of magnetic field and the centre finger points in the direction of current, then the direction in which thumb points, gives the direction of force acting on the conductor.



(a)



(b)

diagrams to illustrate Fleming's left-hand rule

## ELECTRIC MOTOR

A motor is a device which converts electrical energy into mechanical energy. A common electric motor works on direct current, called D.C. motor, which means a '**Direct Current Motor**'.

- (i) **Principle of a Motor :** A motor works on the principle that when a rectangular coil is placed in a magnetic field and current is passed through it, a force acts on the coil which rotates it continuously.
- (ii) **Construction of a Motor :**

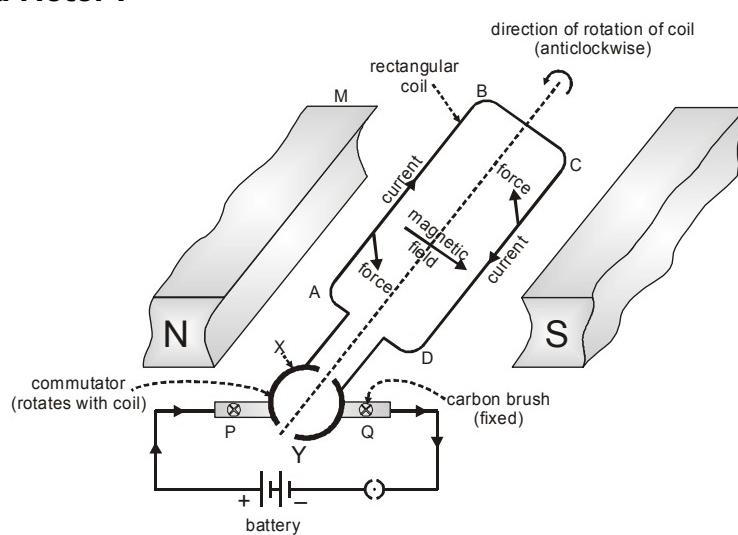


Diagram of Electric Motor

An electric motor consists of a rectangular coil ABCD of insulated copper wire, which is mounted between the curved poles of a horseshoe - type permanent magnet M. The sides AB and CD of the coil are kept perpendicular to the direction of magnetic field between the poles of the magnet. A device which reverses the direction of current through a circuit is called a commutator. The two ends of the coil are soldered permanently to the two half rings X and Y of a commutator. A commutator is a copper ring split into two parts X and Y, these two parts are insulated from one another and mounted on the shaft of the motor.

The commutator rings are mounted on the shaft of the coil and they also rotate when the coil rotates. The function of commutator rings is to reverse the direction of current flowing through



the coil every time the coil just passes the vertical position during a revolution. The carbon brushed P and Q are fixed to the base of the motor and they press lightly against the two half rings of the commutator. The battery to supply current to the coil is connected to the two carbon brushes P and Q through a switch.

The function of carbon brushes is to make contact with the rotating rings of the commutator and through them to supply current to the coil.

- (iii) **Working of a Motor :** When an electric current is passed into the rectangular coil, produces a magnetic field around the coil. Suppose that initially the coil ABCD is in the horizontal position.

The current flows in the direction ABCD and leaves via ring Y and carbon brush Q.

- (a) In the side AB of the rectangular coil ABCD, the direction of current is from A to B. And in the side CD of the coil, the direction of current is from C to D.

By applying Fleming's left hand rule to sides AB and CD of the coil we find that the force on side AB of the coil is in the downward direction whereas the force on side CD of the coil is in the upward direction. Due to this the side AB of the coil is pushed down and side CD of the coil pushed up. The coil ABCD rotates in the anti clockwise direction.

- (b) While rotating, when the coil reaches vertical position, then the brushes P and Q will touch the gap between the two commutator rings and current to the coil is cut off. The coil does not stop rotating because it has already gained momentum due to which it goes beyond the vertical position.

- (c) After half rotation, when the coil goes beyond vertical position, the side CD of the coil comes on the left side whereas side AB of the coil comes to the right side, and the two commutator half rings automatically change contact from one brush to the other. So after half rotation of the coil, the commutator half ring Y makes contact with brush P whereas the commutator half ring X makes contact with brush Q. This reverses the direction of current in the coil. Due to this side CD of the coil is pushed down and the side AB of coil is pushed up. This makes the coil rotates anticlockwise by another half rotation.

- (d) The reversing of current in the coil is repeated after every half rotation due to which the coil continues to rotate as long as current from the battery is passed through it. The rotating shaft of electric motor can drive a large number of machines which are connected to it.

## ELECTROMAGNETIC INDUCTION

- (i) **Electricity From Magnetism :** The production of electricity from magnetism is called electromagnetic induction. The current produced by moving a straight wire in a magnetic field (or by moving a magnet in a coil) is called induced current.

The Phenomenon of electromagnetic induction was discovered by a British Scientist Michael Faraday and an American scientist Joseph Henry independently in 1831. The process of electromagnetic induction has led to the construction of generators for producing electricity at power stations. A galvanometer is an instrument which can detect the presence of electric current in a circuit.

- (ii) **To demonstrate electromagnetic induction by using a coil and a bar magnet :**

We have fixed coil of wire AB. The two ends of the coil are connected to a current detecting instrument called galvanometer.

When a bar magnet is held standstill inside the hollow coil of wire, there is no deflection in the galvanometer pointer showing that no electric current is produced in the coil.

When a bar magnet is moved quickly into a fixed coil of wire AB, then a current is produced in



the coil. This current causes a deflection in the galvanometer pointer.

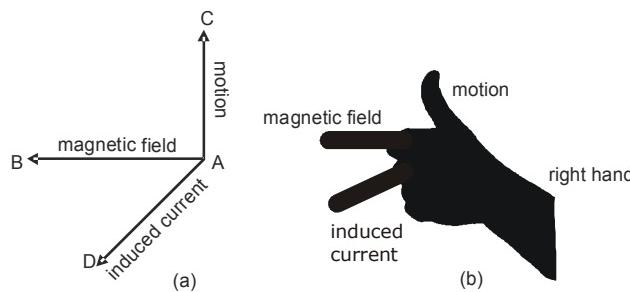
The production of electric current by moving a magnet inside a fixed coil of wire is also a case of electromagnetic induction. The condition necessary for the production of electric current by electromagnetic induction is that there must be a relative motion between the coil of wire and a magnet.

**(iii) Faraday and Henry made the following observations about electromagnetic induction :**

- A current is induced in a coil when it is moved (or rotated) relative to a fixed magnet.
- A current is also induced in a fixed coil when a magnet is moved (or rotated) relative to the fixed coil.
- No current is induced in a coil when the coil and magnet both are stationary relative to one another.
- When the direction of motion of coil (or magnet) is reversed, the direction of current induced in the coil also gets reversed.
- The magnitude of current induced in the coil can be increased :
  - By winding the coil on a soft iron core,
  - By increasing the number of turns in the coil,
  - By increasing the strength of magnet, and
  - By increasing the speed of rotation of coil (or magnet).

### FLEMING'S RIGHT HAND RULE FOR THE DIRECTION OF INDUCED CURRENT

**(i) According to Fleming's right hand rule :** Hold the thumb, the forefinger and the centre finger of your right hand at right angles to one another. Adjust your hand in such a way that forefinger points in the direction of magnetic field and thumb points in the direction of motion of conductor, then the direction in which centre finger points, gives the direction of induced current in the conductor.

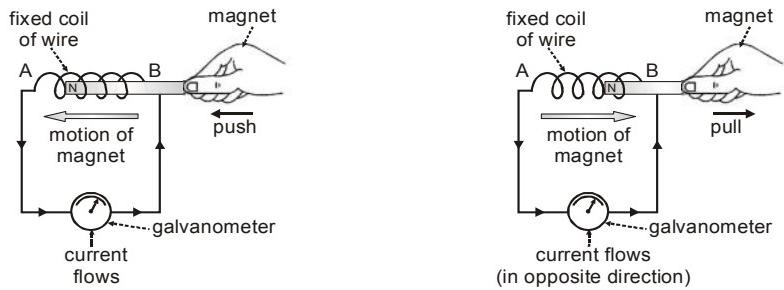


### ELECTRIC GENERATOR

The electric generator converts mechanical energy into electrical energy. A small generator is called a dynamo.

**(i) Principle of Electric Generator :** The electric generator works on the principle that when a straight conductor is moved in a magnetic field, then current is induced in the conductor.





(ii) **Electric generators are of two types :**

- (a) Alternating current generator (A.C. generator)
- (b) Direct Current generator (or D.C. generator)

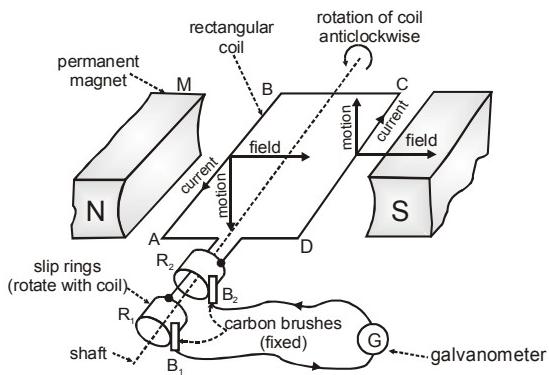
**(a) A.C. GENERATOR :**

• **Construction of an A.C. Generator :** A simple A.C. generator consists of a rectangular coil ABCD which can be rotated rapidly between the poles N and S of a strong horseshoe type permanent magnet M. The coil is made of a large number of turns of insulated copper wire.

The two ends A and D of the rectangular coil are connected to two circular pieces of copper metal called slip rings  $R_1$  and  $R_2$ . As the slip rings  $R_1$  and  $R_2$  rotate with the coil, the two fixed pieces of carbon called carbon brushes,  $B_1$  and  $B_2$  keep contact with them.

The outer ends of carbon brushes are connected to a galvanometer to show the flow of current in the external circuit.

• **Working of an A.C. generator :**



Suppose that the generator coil ABCD is initially in the horizontal position.

(i) As the coil rotates in the anticlockwise direction, the side AB of the coil moves down cutting the magnetic field lines near the N pole of the magnet, and side CD moves up, cutting the magnetic field lines near the S-pole of the magnet. Due to this, induced current is produced in the sides AB and CD of the coil. On applying Fleming's right hand rule to the sides AB and CD of the coil, we find that the currents are in the directions B to A and D to C. Thus, the induced currents in the two sides of the coil are in the same direction. Thus, in the first half revolution of coil, the current in the external circuit flows from brush  $B_1$  to  $B_2$ .

(ii) After half revolution, the sides AB and CD of the coil will interchange their positions. The side



AB will come on the right hand side and side CD will come on the left side.

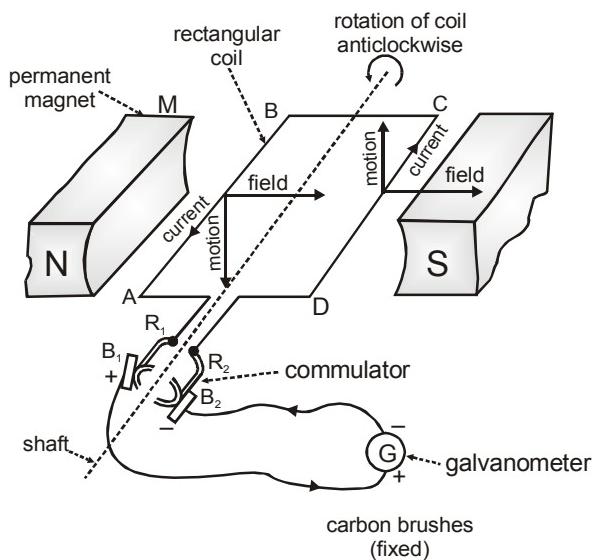
So, after half a revolution, side AB starts moving up and side CD starts moving down.

As a result of this, the direction of induced current in each side of the coil is reversed after half a revolution giving rise to the net induced current in the direction CDAB. The current in the external circuit now flows from brush  $B_2$  to  $B_1$ . Thus, in 1 revolution of the coil, the current reverse its direction 2 times. In this way alternating current is produced in this generator.

- (iii) The alternating current (A.C.) produced in India has a frequency of 50 Hz. A.C. generators are used in power stations to generates electricity.

#### (b) D.C. GENERATOR :

In order to obtain direction current (which flows in one direction only), a D.C. generator is used. Actually, If we replace the slip rings of an A.C. generator by a commutator, then it will become a D.C. generator. Thus, in a D.C. generator, a split ring type commutator is used (like the one used in an electric motor). When the two half rings of commutator are connected to the two ends of the generator coil, then one carbon brush is at all times in contact with the coil arm moving down in the magnetic field while the other carbon brush always remains in contact with the coil arm moving up in the magnetic field. Due to this, the current in outer circuit always flows in one direction. So, it is direct current.



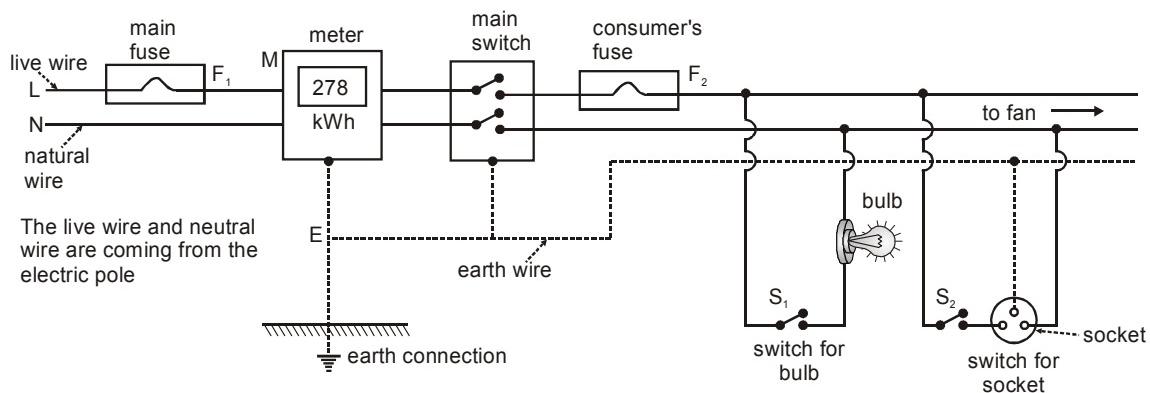
### DOMESTIC ELECTRIC CIRCUIT (OR DOMESTIC WIRING)

Electric power is usually generated at places which are very far from the places where it is consumed. At the generating station, the electric power is generated at 11,000 volt (because voltage higher than this causes) insulation difficulties, while the voltage lower than this involves high current). This voltage is alternating of frequency 50 Hz. (i.e. changing its polarity 50 times in a second). The power is transmitted over long distances at high voltage to minimise the loss of energy in the transmission line wires. For a given electric power, the current becomes low at a high voltage and therefore the loss of energy due to heating ( $= I^2 Rt$ ) becomes less. thus, the alternating voltage is stepped up from 11 kV to 132 kV at the generating station (called grid sub station). It is then transmitted to the main sub station. At the main sub station, this voltage is stepped down to 33 kV and is transmitted to the switching transformer station or the city sub station. At the city sub station, it is further stepped down to 220 kV for supply to the consumer as shown in figure.



To supply power to a house either the overhead wires on poles are used or an underground cable is used before the electric line is connected to the meter in a house, a fuse of high rating ( $\approx 50$  A) is connected at the pole or before the meter. This is called the company fuse. The cable used for connection has three wires (i) live (or phase) wire, (ii) neutral wire, (iii) earth wire. The neutral and the earth wires are connected together at the local sub station, so the neutral wire is at the earth potential. After the company fuse, the cable is connected to a kWh meter. From the meter, connections are made to the distribution board through a main fuse and a main switch.

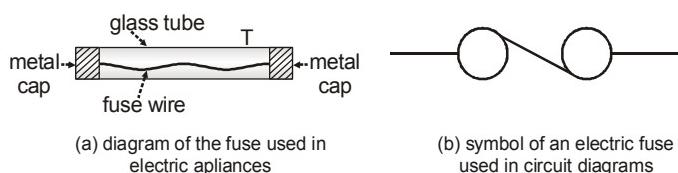
The main switch is a double pole switch. It has iron covering. The covering is earthed. This switch is used to cut the connections of the live as well as the neutral wires simultaneously. The main switch and the meter are locally earthed (in the compound of house). From the distribution board, the wires go to the different parts of the house.



## ELECTRIC FUSE

The electric wires used in domestic wiring are made of copper metal because copper is a good conductor of electricity having very low resistance.

If the current passing through wires exceeds this maximum value, the copper wires get overheated and may even cause a fire. An extremely large current can flow in domestic wiring under two circumstances: short circuiting and overloading.



**(i) Short circuiting :** If the plastic insulation of the live wire and neutral wire gets torn, then the two wires touch each other. This touching of the live wire and neutral wire directly is known as short circuit.

**(ii) Overloading :** If too many electrical appliances of high power rating are switched on at the same time, they draw an extremely large current from the circuit. This is known as overloading the circuit. Overloading can also occur if too many appliances are connected to a single socket.



## MAGNETIC EFFECTS OF ELECTRIC CURRENT

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A fuse is a safety device having a short length of a thin, tin plated copper wire having low melting point, which melts and breaks the circuit if the current exceeds a safe value.

An electric fuse works on the heating effect of current. A fuse wire is connected in series in the electric circuit.



## SOLVED PROBLEMS

**Ex.1** Give some basic properties of magnets :

**Sol.** Some basic properties of magnets are as follows :

**(i) Attractive property :**

A magnet attracts small pieces of iron, cobalt, nickel, etc.

**(ii) Directive property :**

A freely suspended magnet aligns itself nearly in the north-south direction.

**(iii) Law of magnetic poles :**

Like magnetic poles repel and unlike magnetic poles attract each other.

**(iv) Magnetic poles exist in pairs :**

If we break a magnet into two pieces, we always get two small dipole magnets. It is not possible to obtain an isolated N-pole or S-pole.

**Ex.2** What are magnetic lines of force. Give their important properties :

**Sol.** **Magnetic lines of force :**

A magnetic line of force may be defined as the curve the tangent to which at any point gives the direction of the magnetic field at that point. It may also be defined as the path along with a free north pole tends to move.

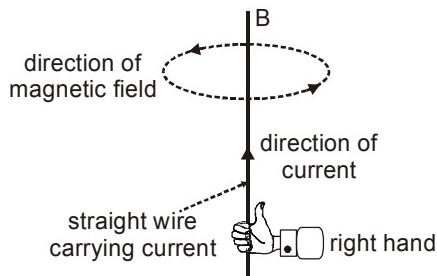
**Properties of lines of force :**

- (i) These are closed curves which start in air from the N-pole and end at the S-pole or i then return to the N-pole through the interior of the magnet.
- (ii) No two magnetic lines of force can intersect each other.
- (iii) They start from and end on the surface of the magnet normally.
- (iv) The lines of force have a tendency to contract lengthwise and expand sidewise. This explains attraction between unlike poles and repulsion between like poles.
- (v) The relative closeness of the lines of force gives a measure of the strength of the magnetic field which is maximum at the poles.

**Ex.3** Name and state the two rules for finding the direction of magnetic field produced by electric current through a straight conductor.

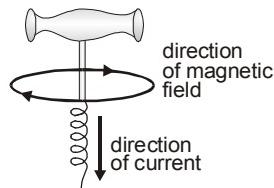
**Sol.** The direction of the magnetic field produced by a current carrying straight conductor can be obtained by using any of the following two rules :

**(i) Right hand thumb rule :**



If the current carrying conductor is held in the right hand such that the thumb points in the direction of the current, then the direction of the curl of the fingers will give the direction of the magnetic field, as shown in figure.

**(ii) According to Maxwell's corkscrew rule :**



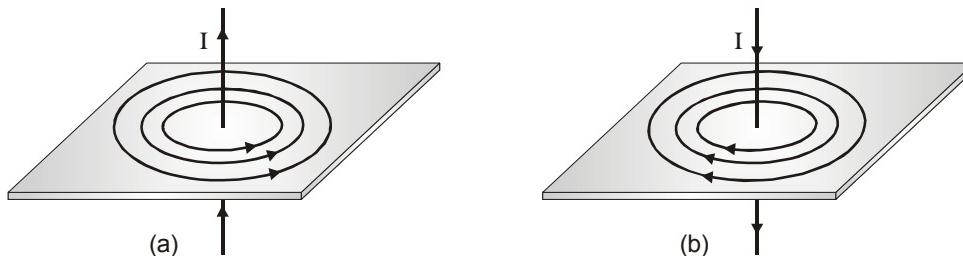
Imagine driving a corkscrew in the direction of current, then the direction in which we turn its handle is the direction of magnetic field (or magnetic field lines).



## MAGNETIC EFFECTS OF ELECTRIC CURRENT

- Ex.4** A straight conductor is held perpendicular to the plane of paper and it carries a current (a) upwards, (b) downwards, Draw the magnetic lines of force ?

**Sol.** (a) See figure (a) Lines of force have anticlockwise sense.  
 (b) See figure (b) Lines of force clockwise sense.

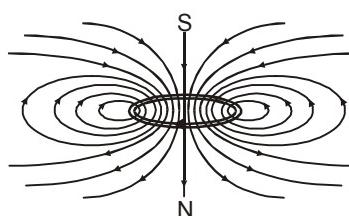


- Ex.5** Draw and discuss the pattern of the magnetic lines of force of a current carrying circular loop.

**Sol.** **Magnetic field due to a current through a circular loop :**

The magnetic field lines of a circular wire carrying a current. The lines of force near the wire are almost concentric circles. As we move towards the centre of loop, the concentric circles become larger and larger. Near the centre of the loop, the areas of these big circles appear as parallel straight lines.

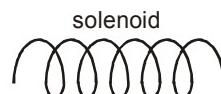
Thus the magnetic field is almost uniform at the centre of the loop. By applying right hand rule, we can see that the magnetic field lines due to all sections of the wire are in the same direction within the loop.



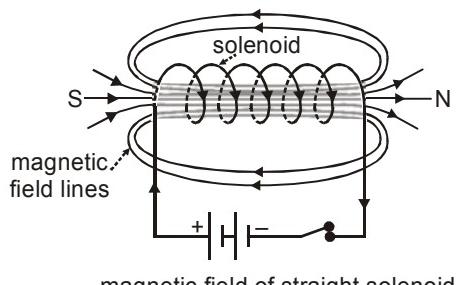
- Ex.6** (a) What is a solenoid ?

(b) Draw a rough sketch of the pattern of the filed lines due to a solenoid carrying current?  
 (c) Compare the magnetic behaviour of a straight solenoid with that of a bar magnet ?  
 (d) ON what factors does the strength of the magnetic field produced by a current carrying solenoid depend?

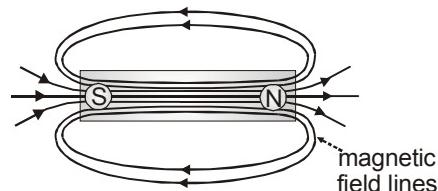
**Sol.** (a) **Solenoid :** A long cylindrical coil of insulated copper wire of large number of circular turns is called a solenoid.



- (b) When an electric current is passed through a solenoid, it produces a magnetic field around it. Its magnetic field pattern is shown in figure.



magnetic field of straight solenoid



magnetic field of bar magnet



(c) When a current is passed through the solenoid, the current in each circular loop has the same direction, their magnetic effects get added up producing a strong magnetic field.

Inside the solenoid, the magnetic field is almost uniform and parallel to the axis of the solenoid. The magnetic field produced by a solenoid is very much, similar to that of magnet like a bar magnet, one end of the solenoid has N polarity while other end has S-polarity.

The polarity of any end (face) of the coil can be determined by clock rule.

For all practical purposes, the magnetic field of a solenoid and that of a bar at can be taken identical.

(d) Factors on which the strength of the magnetic field produced by a current solenoid depends :

**(i) Number of turns in the solenoid :**

The larger the number of turns in the stronger is the magnetic field produced.

**(ii) Strength of the current :**

The larger the current passed through the solenoid is the magnetic field produced.

**(iii) Nature of the core material :**

By winding the coil over a soft iron cylinder, core, the magnetic field can be increased several thousands times.

**Ex.7** What is an electromagnet ? On factors does the strength of an electromagnet depend ?

**Sol. Electromagnet :**

A soft iron core placed inside a solenoid behaves like a powerful when a current is passed through a solenoid. This device is called an electromagnet.

The current is switched off, the iron core loses its magnetism and so it is no longer an electromagnet. Thus, electromagnet are temporary magnets.

Factors on which the strength of an electromagnet depends :

**(i) Number of turns in the coil :**

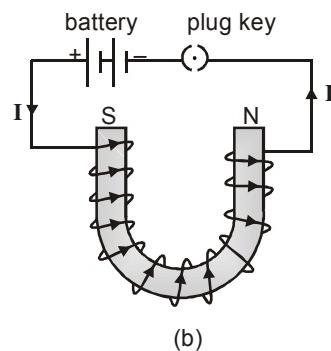
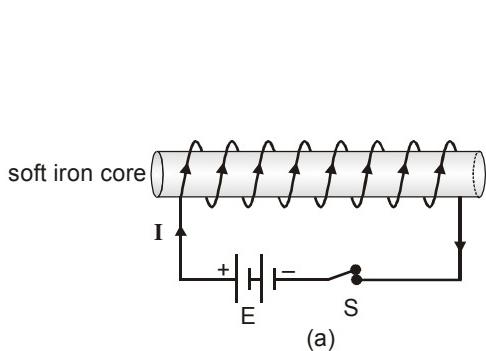
The larger the number of turns in the coil, is the strength of the electromagnet.

**(ii) Strength of the current :**

The larger the current passed through the solenoid, powerful is the electromagnet.

**(iii) Nature of the core material :**

The core of the magnetic material like soft iron the strength of the electromagnet.



## MAGNETIC EFFECTS OF ELECTRIC CURRENT

**Ex.8** Name and state the rule to determine the direction of a force experienced by a straight conductor carrying current placed in a magnetic field which is perpendicular to it.

**Sol.** Fleming's left hand rule. Stretch the forefinger, the central finger and the thumb of the left hand mutually perpendicular to each other.

If the forefinger points in the direction of the magnetic field, the central finger in the direction of current, then the thumb points in the direction of force on the conductor.

**Ex.9** Name and define the SI unit of magnetic field.

**Sol.** SI unit of magnetic field is tesla : (T)

$$\text{As } F = qvB, \text{ so } B = \frac{F}{qv}$$

$$\text{If, } F = 1 \text{ N, } q = 1 \text{ C, } v = \text{ms}^{-1}, \text{ then } [ \because 1 \text{ Cs}^{-1} = 1 \text{ A}]$$

$$\text{SI unit of } B = \frac{1\text{N}}{1\text{C}.1\text{ms}^{-1}} = \frac{1\text{N}}{1\text{A}.1\text{m}}$$

$$\text{or SI unit of } B = 1 \text{ NA}^{-1} \text{ m}^{-1} = 1 \text{ tesla}$$

So, one tesla is that magnetic field in which a charge of one coulomb moving with a velocity of 1 m/s perpendicular to the magnetic field experience a force one newton.

**Ex.10** With the help of a labelled diagram, explain the principle, construction and working of an electric motor. What is the function of a split ring in an electric motor ?

**Sol.** **Electric motor** : We describe here a d.c. motor which operates on direct current obtained from a battery.

**Principle** : An electric motor works on the principle that a current carrying conductor placed in a magnetic field experiences a force, the direction of force is given by Fleming's left hand rule. After half a rotation, as shown in Figure the split ring  $S_1$  comes in contact with bush  $B_2$  and  $S_2$  in contact with brush  $B_1$ .

Therefore, the current in the coil gets reversed and flows along the path DCBA.

A device that reverse the direction of flow of current through a circuit is called commutator. In electric motors, the split ring acts as a commutator.

Thus the arm AB is now pushed up and the arm CD is pushed down.

Therefore, the coil and the axis rotate half a turn more in the same direction.

The reversing of the current is repeated at each half rotation, giving rise to a continuous rotation of the coil and to the axis.

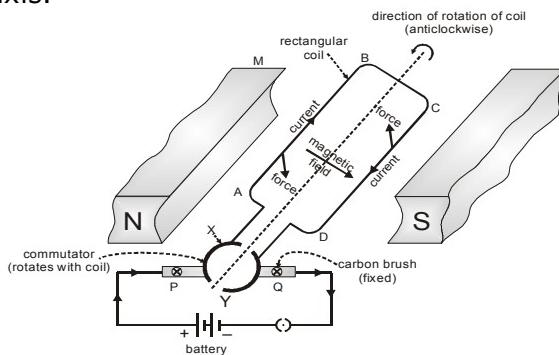


Diagram of Electric Motor

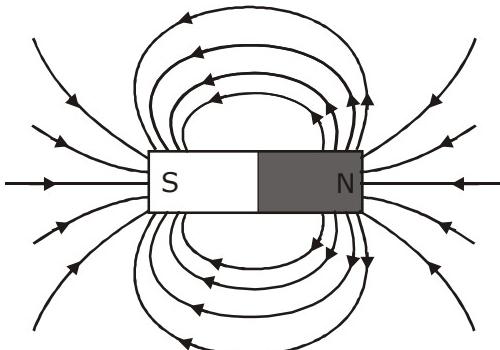


## NCERT QUESTIONS WITH SOLUTIONS

**Q.1** Why does a compass needle get deflected when brought near a bar magnet?

**Ans.** Compass needle is a small magnet which experiences a force in the magnetic field of a bar magnet. Due to this force, it gets deflected.

**Q.2** Draw magnetic field lines around a bar magnet.



**Ans.**

**Q.3** List the properties of magnetic lines of force.

**Ans.** (i) Magnetic lines of force are closed continuous curves.  
(ii) The tangent at any point on the magnetic line of force gives the direction of the magnetic field at that point.  
(iii) Two magnetic lines of force never cross each other.

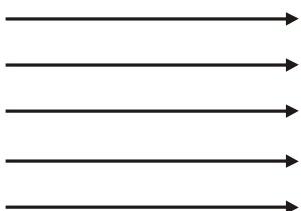
**Q.4** Why do no two magnetic lines of force intersect each other?

**Ans.** The tangent at any point on a magnetic field line gives the direction of magnetic field at that point. If two magnetic field lines cross each other, then at the point of intersection, there will be two tangents. Hence, there will be two directions of the magnetic field at the point of intersection. This is not possible. Hence, no two magnetic field lines can cross each other.

**Q.5** Consider a circular loop of wire lying in the plane of the table. Let the current pass through the loop clockwise. Apply the right hand rule to find out the direction of magnetic field inside and outside the loop.

**Ans.** Magnetic field inside the loop is perpendicular to the plane of table and in the downward direction. Outside the loop, magnetic field is perpendicular to the plane of the table and in the upward direction.

**Q.6** The magnetic field in a given region is uniform. Draw a diagram to represent it.



**Ans.**

**Q.7** Choose the correct option. The magnetic field inside a long straight solenoid-carrying current  
(A) is zero

- (B) decreases as we move towards its ends
- (C) Increases as we move towards its ends.
- (D) is the same at all points.



## MAGNETIC EFFECTS OF ELECTRIC CURRENT

**Ans.** The magnetic field Inside a long straight solenoid-carrying current decreases as we move towards its ends. At the ends of solenoid, the strength of the magnetic field is almost the half that In the middle of the solenoid. Thus, the correct option is (B).

**Q.8** Which of the property a proton can change when it moves freely in a magnetic field? (There may be more than one correct answer)

- (A) mass                    (B) speed                    (C) velocity                    (D) momentum.

**Ans.** Motion of a charged particle like proton in a magnetic field is a circular path. Hence its velocity and momentum can change. Thus, option (B) and (D) are correct.

**Q.9** In activity physics 12.7 (in NCERT), how do we think the displacement of rod PQ will be affected if (i) current in rod PQ is increased (ii) a stronger horseshoe magnet is inserted (iii) length of the rod PQ is increased.

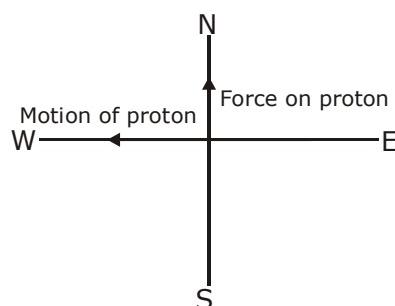
**Ans.** (i) When current in rod increases, force on the rod also increases. Hence, the displacement of the rod increases.

(ii) When a stronger horseshoe magnet is inserted, magnetic field increases. Thus, force on the rod also increases. Hence, displacement of the rod increases.

(iii) When length of the rod increases, force on the rod also increases and hence, displacement increases.

**Q.10** A positively charged particle (alpha particle) projected towards west is deflected towards north by a magnetic field. The direction of magnetic field is

- (A) towards south                    (B) towards east                    (C) downward                    (D) upward



**Ans.**

By applying Fleming's left hand rule, we find that the magnetic field is in upward direction. Thus, option (D) is correct.

**Q.11** State Fleming's left hand rule.

**Ans.** 'Stretch the thumb, forefinger and central finger of your left hand such that they are mutually perpendicular. If the fore finger points in the direction of magnetic field and the central finger in the direction of current, then the thumb will point in the direction of motion or the force acting on the conductor'.

**Q.12** What is the principle of electric motor?

**Ans.** It is based on the principle that a current carrying coil experiences equal and opposite forces, on its edges which rotates it continuously.

**Q.13** What is the role of the split ring in an electric motor?

**Ans.** The split-ring in an electric motor reverses the direction of current in the coil of the motor. Therefore, the direction of the force acting on the two arms of the coil is also reversed. As a result of this, the coil of d.c. motor continues to rotate in the same direction.





## MAGNETIC EFFECTS OF ELECTRIC CURRENT

- Q.24** The device used for producing electric current is called a  
(A) generator      (B) galvanometer      (C) ammeter      (D) motor

**Ans.** Option (A) is correct.

- Q.25** The essential difference between an AC generator and a DC generator is that  
(A) AC generator has an electromagnet while a DC generator has permanent magnet.  
(B) DC generator will generate a higher voltage  
(C) AC generator will generate a higher voltage  
(D) AC generator has slip rings while the DC generator has a commutator.

**Ans.** An AC generator has slip rings while a DC generator has split ring commutator. Thus, option (D) is correct.

- Q.26** At the time of short circuit, the current in the circuit  
(A) reduces substantially      (B) does not change  
(C) increases heavily      (D) varies continuously

**Ans.** Short circuit takes place when the live wire and the neutral wire come into direct contact, the resistance in the circuit becomes very low and the current in the circuit abruptly increases. Thus, option (C) is correct.

- Q.27** State whether the following statements are true or false.  
(A) An electric motor converts mechanical energy into electrical energy.  
(B) An electric generator works on the principle of electromagnetic induction.  
(C) The field at the centre of a long circular coil carrying current will be parallel straight lines.  
(D) A wire with a green insulation is usually the live wire.

**Ans.** (A) False. It converts electrical energy into mechanical energy.  
(B) True.  
(C) True.  
(D) False. Live wire has red insulation cover.

- Q.28** List three sources of magnetic fields.  
**Ans.** (i) a permanent magnet.      (ii) a current carrying solenoid.  
(iii) Current carrying wire.

- Q.29** How does a solenoid behave like a magnet? Can you determine the north and south poles of a current carrying solenoid with the help of a bar magnet. Explain.

**Ans.** When electric current flows through a solenoid, magnetic field is set up around the solenoid. One end of the solenoid behaves as north pole and the other end of the solenoid behaves as south pole. To determine the north and south poles of a current carrying solenoid bring the north pole of a bar magnet towards one end of the solenoid. If the solenoid attracts towards the magnet, then that face of the solenoid is south pole. If the solenoid moves away from the bar magnet, then that face of the solenoid is the north pole.

- Q.30** State the rule to determine the direction of a (i) magnetic field produced around a straight conductor carrying bar current, (ii) force experienced by a current-carrying straight conductor placed in a magnetic field which is perpendicular to it, and (iii) current induced in a coil due to its rotation in a magnetic field.

**Ans.** (i) right hand thumb rule.  
(ii) Fleming's left hand rule.  
(iii) Fleming's right hand rule.



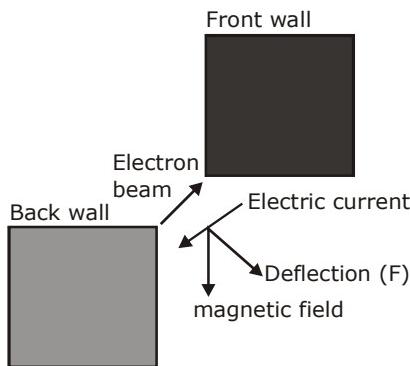
## MAGNETIC EFFECTS OF ELECTRIC CURRENT

**Q.31** When is the force experienced by a current carrying conductor placed in magnetic field the largest ?

**Ans.** When current carrying conductor is placed perpendicular to the magnetic field.

**Q.32** Think you are sitting in a chamber with your back to one wall. An electron beam moving horizontally from back wall towards the front wall, is deflected by a strong magnetic field to your right side. What is the direction of magnetic field?

**Ans.** Movement from electron beam from back wall to the front wall is equivalent to the flow of electric current from front wall to the back wall. The deflection of the beam means, the force is acting towards our right side. According to Fleming's Left Hand Rule, the direction of magnetic field is vertically downward.



**Q.33** A coil of insulated copper wire is connected to a galvanometer. What will happen if a bar magnet is (i) pushed into the coil (ii) withdrawn from inside the coil, (iii) held stationary inside the coil?

**Ans.** (i) When a bar magnet is pushed into the coil, induced current flows through the coil due to the phenomenon of electromagnetic induction. This induced current is indicated by the deflection of the needle of the galvanometer inserted into the coil.

(ii) When a bar magnet is withdrawn from inside the coil, again induced current flows through the coil due to the phenomenon of electromagnetic induction. In this case, the direction of induced current is opposite to the direction of the current in case (i).

(iii) When the bar magnet is held stationary inside the coil, there is no change in magnetic field around the coil. Hence, no induced current flows through the coil. therefore, galvanometer shown no deflection.

**Q.34** Name some devices in which electric motors are used.

**Ans.** Pump sets, electric cars, rolling mills, electric fans, hair drier, etc.

**Q.35** Two circular coils A and B are placed close to each other. If the current in the coil A is changed, will some current be induced in the coil B? Given reason.

**Ans.** When current in coil A is changed, a changing magnetic field is set up around it. this changing magnetic field also links with coil B and hence some current will be induced in coil B due to electromagnetic induction.

**Q.36** When does an electric short circuit occur?

**Ans.** when live wire and neutral wire touch each other (i.e. come in direct contact).

**Q.37** What is the function of an earth wire? Why is it necessary to earth metallic casings of electric appliances.

**Ans.** Earth wire acts as a safety measure. When the live wire touches the metallic casing of an electric appliance, the electric current flows from the casing of the appliance to the earth through the copper wire. An electric current flows in the direction of low resistance thus, current passes through the copper wire instead of human body. Thus, the human body is saved from electric shock.



**EXERCISE – I****BOARD PROBLEMS**

- Q.1** What is a magnet ?
- Q.2** What is a natural magnet ?
- Q.3** What is the meaning of the word lodestone?
- Q.4** What is the origin of the word magnetism ?
- Q.5** State the law of magnetic poles ?
- Q.6** What is the cause of magnetism ?
- Q.7** What happens if a bar magnet is cut into two pieces (i) transverse to its length (ii) along its length ?
- Q.8** Are the two poles of a magnet equally strong?
- Q.9** Define the term magnetic field ?
- Q.10** Define a magnetic line of force ?
- Q.11** Give two properties of magnetic lines of force
- Q.12** Can two magnetic lines of force intersect ? Justify your answer.
- Q.13** Magnetic lines of force are endless ? Comment
- Q.14** A freely suspended magnet always points along north-south direction. Give reason ?
- Q.15** Name the scientist who first established a connection between electricity and magnetism.
- Q.16** What is magnetic effect of current ?
- Q.17** State Oersted observation ?  
**OR**  
How can it be shown that a magnetic field exists around a wire through which a direct electric current is passing ?
- Q.18** What is the nature of the magnetic field associated with a straight current carrying conductor ?
- Q.19** State the right hand rule for finding the direction of magnetic field of a straight current carrying conductor ?
- Q.20** How can we locate a current carrying wire concealed in a wall ?
- Q.21** What does an electric current carrying wire behaves like?
- Q.22** Define magnetic field?
- Q.23** Define field lines?
- Q.24** What kind of quantity is magnetic field?
- Q.25** What is a compass needle?
- Q.26** State Fleming's left hand rule.
- Q.27** State and explain how right hand thumb rule indicates magnetic field.
- Q.28** Why do we use power supply of two different current ratings at our homes?
- Q.29** What is an electric fuse? What material is selected for fuse wire?
- Q.30** Give four features of domestic electric wiring.
- Q.31** (a) What is meant by a magnetic field?  
(b) How is the direction of magnetic field at a point determined?  
(c) What is the direction of magnetic field at the centre of a current- carrying circular loop.
- Q.32** (a) What is an electromagnet? What does it consist of?  
(b) Name one material in each case which is used to make a  
(i) Permanent magnet  
(ii) Temporary magnet



## **EXERCISE – II**

# **NTSE /OLYMPIAD /FOUNDATION PROBLEMS**





- Q.28** Potential difference between a live wire and the neutral wire is :  
 (A) 150 V                    (B) 210 V  
 (C) 200 V                    (D) 220 V.

**Q.29** Which of the following statements is incorrect regarding magnetic field lines :  
 (A) The direction of magnetic field at a point is taken to be the direction in which the north pole of a magnetic compass needle points  
 (B) Magnetic field lines are closed curves  
 (C) If magnetic field lines are parallel and equidistant, they represent zero field strength  
 (D) Relative strength of magnetic field is shown by the degree of closeness of the field lines

**Q.30** Magnetic field lines determine :  
 (A) The shape of the magnetic field  
 (B) Only the direction of the magnetic field  
 (C) Only the relative strength of the magnetic field  
 (D) Both the direction and the relative strength of the magnetic field

**Q.31** The magnetic field near a long straight wire is described by :  
 (A) Straight field lines parallel to the wire  
 (B) Straight field lines perpendicular to the wire  
 (C) Concentric circles centered on the wire  
 (D) Radial field lines starting from the wire

**Q.32** Magnetic field inside a long solenoid carrying current is :  
 (A) Same at all points  
 (B) Minimum in the middle  
 (C) More at the ends than at the centre  
 (D) Found to increase from one end to the other.

**Q.33** The frequency of direct current is :  
 (A) Zero                      (B) 50 Hz  
 (C) 60 Hz                    (D) 100 Hz.

**Q.34** The frequency of household supply of a.c. in India is :  
 (A) Zero                      (B) 50 Hz  
 (C) 60 Hz                    (D) 100 Hz.

**Q.35** The most important safety device method used for protecting electrical appliances from short circuiting or overloading is :  
 (A) Earthing  
 (B) Use of stabilizers  
 (C) Use of electric meter  
 (D) Use of fuse

**Q.36** Current flowing in conductor A is 2A and current flowing in conductor B is 4A. The ratio of magnetic field produced around conductor A to the magnetic field produced around conductor B at a distance 10 cm from both the conductors is :  
 (A) 2 : 1                    (B) 1 : 2  
 (C) 4 : 1                    (D)  $\sqrt{2}$  : 1

**Q.37** Current flowing in conductors A and B is same, what is the ratio of the magnetic field produced around the conductor A at a distance of 5 cm from the conductor to the magnetic field produced around the conductor B at a distance of 2 cm from this conductor is  
 (A) 0.04                    (B) 0.4  
 (C) 4.0                     (D) 10

**Q.38** Same amount of current flows in the same direction along the two parallel conductors separated by a small distance :  
 (A) Both conductors attract each other  
 (B) Both conductors repel each other  
 (C) Conductors neither attract each other nor repel each other  
 (D) Both conductors rotates about their axis.

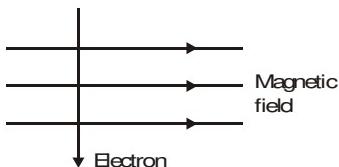
- Q.39** Magnetic field produced at the centre of a current carrying circular wire is :
- Directly proportional to the square of the radius of the circular wire
  - Directly proportional to the radius of the circular wire
  - Inversely proportional to the square of the radius of the circular wire
  - Inversely proportional to the radius of the circular wire.
- Q.40** Magnitude of magnetic field intensity at a point around a current carrying conductor is  $B$ . If the strength of current in the conductor becomes double, then the magnitude of magnetic field intensity at the point around the conductor is :
- $\frac{B}{2}$
  - $B$
  - $\frac{B}{4}$
  - $2B$
- Q.41** Two parallel conductor carrying current in the opposite directions
- Repel each other
  - Attract each other
  - Sometimes attract and sometimes repel each other
  - None of these
- Q.42** Force acting on a stationary charge  $Q$  in the magnetic field  $B$  is :
- $B Q v$
  - $B Q / v$
  - $B v / Q$
  - Zero
- Q.43** A current carrying conductor placed perpendicular to the magnetic field experience a force. The displacement of this conductor in the magnetic field can be increased by.
- Decreasing the magnetic field
  - Decreasing the current in the conductor
  - Increasing the magnetic field
  - Decreasing the length of the conductor.
- Q.44** A conductor of length 50 cm, carrying current of 0.1 A, when placed perpendicular to direction of magnetic field 0.2 T experience force :
- 1.0 N
  - 0.1 N
  - 0.01 N
  - 0.01 N.
- Q.45** A charged particle having charge  $1.6 \times 10^{-19} \text{ C}$  travels with a speed of  $3.2 \times 10^6 \text{ ms}^{-1}$  in a direction parallel to the direction of magnetic field 0.04 T. The force experienced by the particle is :
- $2.0 \times 10^{-14} \text{ N}$
  - $0.2 \times 10^{-14} \text{ N}$
  - Zero
  - $4.0 \times 10^{-14} \text{ N}$
- Q.46** A magnetic compass is placed near a current carrying wire. The deflection of the needle of the magnetic compass increases. It shows that:
- Current in the wire is decreasing
  - Current in the wire is increasing
  - Current in the wire has nothing to do with the deflection of the needle of the magnetic compass
  - Magnetic compass has been disturbed by some one.
- Q.47** A soft iron rod can be made an electro-magnet. Which of the following procedures would be adopted to test that the soft iron rod had become a magnet ?
- Place the iron rod near a bar magnet and observe if it attracts iron pins
  - Place the iron rod near a current carrying wire and observe if it attracts iron pins
  - Place the iron rod inside a current carrying solenoid and observe if it attracts iron pins
  - None of these.



**Q.48** Current can be made to flow through a coil without connecting the coil with a battery. Which of the following procedures would be most suited to test this fact ?

- (A) Connect a galvanometer across the ends of the coil and observe if galvanometer shows a deflection, when a bar magnet is placed near the one end of the coil.
  - (B) Connect a galvanometer across the ends of the coil and observe if galvanometer shows a deflection, when a bar magnet is placed inside the coil.
  - (C) Connect the galvanometer across the ends of the coil and observe if galvanometer shows a deflection, when a bar magnet is moved towards or away from the coil and along the axis of the coil.
  - (D) None of these

**Q.49** An electron enters a magnetic field at right angles to it as shown in figure. The direction of force acting on the electron will be [NTSE]



- (A) To the right
  - (B) To the left
  - (C) Out of the page
  - (D) Into the page.

**Q.50** An election moving with uniform velocity in x direction enters a region of uniform magnetic field along y direction.

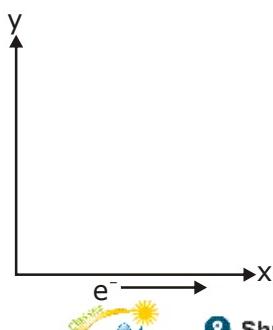
Which of the following physical quantities is (are) non-zero and remain constant? [NTSE]

- I. Velocity of the electron.
  - II. Magnitude of the momentum of the electron.
  - III. Force on the electron.
  - IV. The kinetic energy of electron

(A) I and II                    (B) II and IV  
(C) II, III and IV            (D) II and IV

ANSWER KEY

- |            |   |            |   |            |   |            |   |
|------------|---|------------|---|------------|---|------------|---|
| <b>1.</b>  | B | <b>2.</b>  | C | <b>3.</b>  | A | <b>4.</b>  | B |
| <b>5.</b>  | D | <b>6.</b>  | C | <b>7.</b>  | A | <b>8.</b>  | B |
| <b>9.</b>  | C | <b>10.</b> | D | <b>11.</b> | A | <b>12.</b> | C |
| <b>13.</b> | D | <b>14.</b> | B | <b>15.</b> | C | <b>16.</b> | C |
| <b>17.</b> | A | <b>18.</b> | C | <b>19.</b> | C | <b>20.</b> | C |
| <b>21.</b> | D | <b>22.</b> | C | <b>23.</b> | C | <b>24.</b> | B |
| <b>25.</b> | D | <b>26.</b> | D | <b>27.</b> | D | <b>28.</b> | D |
| <b>29.</b> | C | <b>30.</b> | D | <b>31.</b> | C | <b>32.</b> | A |
| <b>33.</b> | A | <b>34.</b> | B | <b>35.</b> | D | <b>36.</b> | B |
| <b>37.</b> | B | <b>38.</b> | A | <b>39.</b> | D | <b>40.</b> | D |
| <b>41.</b> | A | <b>42.</b> | D | <b>43.</b> | C | <b>44.</b> | C |
| <b>45.</b> | C | <b>46.</b> | B | <b>47.</b> | C | <b>48.</b> | C |
| <b>49.</b> | C | <b>50.</b> | D |            |   |            |   |



## **EXERCISE – III**

# **ISO / NESTSE / IJO QUESTIONS**

## **OBJECTIVE TYPE QUESTIONS**

## **CHOOSE THE CORRECT ONE**



conductor in a magnetic field is

- (1) Generator                          (2) Accelerator  
(3) Motor                              (4) Transformer



- 12.** In domestic electric circuits, fuse must be placed in series with

  - (1) Earth wire
  - (2) Neutral wire
  - (3) Live wire
  - (4) Any of the three wires.

- 13.** Electric and main switch is contained in a main board fitted usually

  - (1) At street electric pole
  - (2) At main gate of building
  - (3) In varandah or poarch
  - (4) In bed or study room.

- 14.** High powered electrical appliances are earthed to

  - (1) Avoid shock
  - (2) Avoid wastage
  - (3) Make the appliance look beautiful
  - (4) Reduce the bill.

- 15.** In a three pin socket (shoe) the bigger hole is connected to  
(1) Any wire                          (2) Live wire  
(3) Neutral wire                      (4) Earth wire.

- 16.** Due to overloading, the current in circuit becomes  
(1) Less                          (2) More  
(3) Zero                            (4) Not definite.

- 17.** Coming of live wire and neutral wire in direct contact causes

- (1) Short-circuiting      (2) Over-loading  
(3) No damage            (4) Unknown effect.

- 18.** Melting point of material of a fuse wire must be  
(1) Moderate              (2) High





- wires.
- 33.** When a fuse is rated at 8 A, it means :
- it will not work if current is less than 8 A
  - it has a resistance of 8 ohm
  - it will work only if current is 8 A
  - it will burn if current exceeds 8 A.
- 34.** According to International Convention of colour coding of wires used in household electrical circuits :
- live is red, neutral is black and earth is green
  - live is red, neutral is green and earth is black
  - live is brown, neutral is blue and earth is black
  - live is brown, neutral is light blue and earth is green.
- 35.** The magnetic field lines inside a current carrying solenoid are :
- along the axis and parallel to each other
  - perpendicular to the axis and equidistant from each other
  - circular and they do not intersect each other
  - circular at the ends but they are parallel to the axis inside the solenoid
- 36.** Potential difference between a live wire and the neutral wire is :
- 150 V
  - 210 V
  - 200 V
  - 220 V.
- 37.** Which of the following statements is incorrect regarding magnetic field lines :
- The direction of magnetic field at a point is taken to be the direction in which the north pole of a magnetic compass needle points
  - Magnetic field lines are closed curves
  - If magnetic field lines are parallel and equidistant, they represent zero field strength
  - Relative strength of magnetic field is shown by the degree of closeness of the field lines
- 38.** Magnetic field lines determine :
- The shape of the magnetic field
  - Only the direction of the magnetic field
  - Only the relative strength of the magnetic field
  - Both the direction and the relative strength of the magnetic field
- 39.** The magnetic field near a long straight wire is described by :
- Straight fieldlines parallel to the wire
  - Straight field lines perpendicular to the wire
  - Concentric circles centred on the wire
  - Radial field lines starting from the wire
- 40.** The phenomenon of electromagnetic induction is :
- The process of charging a sphere.
  - The process of producing magnetic field in a coil
  - The process of producing induced current in a coil whenever there is a relative motion between the coil and the magnet.
  - The process of producing cooling effect.
- 41.** Potential difference between a live wire and the neutral wire is :
- 200 volt
  - 150 volt
  - 210 volt
  - 220 volt
- 42.** A rectangular coil of copper wires is rotated in a magnetic field. The direction of the induced current changes once in each :
- One revolution
  - One-fourth revolution
  - Half revolution
  - Two revolutions.
- 43.** Magnetic field inside a long solenoid carrying current is :
- Same at all points
  - Minimum in the middle
  - More at the ends than at the centre
  - Found to increase from one end to the other.
- 44.** At the time of short circuit, the current in the circuit :
- Vary continuously
  - Reduces considerably
  - Increases heavily
  - does not change.
- 45.** The frequency of direct current is :
- Zero
  - 50 Hz
  - 60 Hz
  - 100 Hz.
- 46.** The frequency of household supply of a.c. in India is :
- Zero
  - 50 Hz
  - 60 Hz
  - 100 Hz.
- 47.** The most important safety device method used for protecting electrical appliances from short circuiting or overloading is :





**In these type of Questions, two statements are given. Choose the correct option by following directions given below : (Q. 80 to 83)**

**(1) Statement I is correct and Statement II is correct explanation of the statement I.**

**(2) Statement I is correct  
but Statement II is not the correct**

## **explanation of the statement I.**

- (3) **Statement I is true but statement II is not true.**

(4) **Statement I is not true but statement II is true.**

62. **Statement I :** A soft iron bar placed inside a solenoid carrying current is magnetised.

**Statement II :** Magnetic field inside a long solenoid carrying current is non-uniform.

(1) A (2) B  
(3) C (4) D

63. **Statement I :** The strength of magnetic field of a permanent magnet decreases with the increase in temperature.

**Statement II :** A permanent magnet can be demagnetised by heating it.

(1) A (2) B  
(3) C (4) D

64. **Statement I :** A charged particle moving parallel to the direction of magnetic field experiences a force.

**Statement II :** A charged particle moving at right angle to the direction of magnetic field experiences maximum force.

(1) A (2) B  
(3) C (4) D

65. A current carrying conductor placed perpendicular to the magnetic field experience a force. The displacement of this conductor in the magnetic field can be increased by.

(1) Decreasing the magnetic field  
(2) Decreasing the current in the conductor  
(3) Increasing the magnetic field  
(4) Decreasing the length of the conductor.

66. A conductor of length 50 cm, carrying current of 0.1 A, when placed perpendicular to direction of magnetic field 0.2 T experience force :

(1) 1.0 N (2) 0.1 N  
(3) 0.01 N (4) 0.01 N.

67. A charged particle having charge  $3.2 \times 10^{-19}$  C is travelling with a speed of  $1.0 \times 10^6$  ms<sup>-1</sup>.



When it passes perpendicular to the magnetic field  $0.4\text{ T}$ , then the force experienced by it is :

- (1)  $12.8 \times 10^{-13}\text{ N}$
- (2)  $1.28 \times 10^{-13}\text{ N}$
- (3)  $19.2 \times 10^{-15}\text{ N}$
- (4)  $1.92 \times 10^{-15}\text{ N}$ .

**68.** A charged particle having charge  $1.6 \times 10^{-19}\text{ C}$  travels with a speed of  $3.2 \times 10^6\text{ ms}^{-1}$  in a direction parallel to the direction of magnetic field  $0.04\text{ T}$ . The force experienced by the particle is :

- (1)  $2.0 \times 10^{-14}\text{ N}$
- (2)  $0.2 \times 10^{-14}\text{ N}$
- (3) Zero
- (4)  $4.0 \times 10^{-14}\text{ N}$

**69.** A magnetic compass is placed near a current carrying wire. The deflection of the needle of the magnetic compass increases. It shows that :

- (1) Current in the wire is decreasing
- (2) Current in the wire is increasing
- (3) Current in the wire has nothing to do with the deflection of the needle of the magnetic compass
- (4) Magnetic compass has been disturbed by some one.

**70.** A charged particle moving in a magnetic field experience a maximum force, when it moves at right angle to the direction of magnetic field. However, a student observes that a charged particle moving in the region of a magnetic field experiences no force and continues to move in a straight line. The observation of the student is correct only if :

- (1) Charged particle moves at an angle of  $30^\circ$  with the magnetic field
- (2) Charged particle moves at an angle of  $60^\circ$  with the magnetic field
- (3) Charged particle either moves parallel or anti-parallel to the magnetic field
- (4) Charged particle can never move in a straight line in the magnetic field.

**71.** A soft iron rod can be made an electro-magnet. Which of the following procedures would be

adopted to test that the soft iron rod had become a magnet ?

- (1) Place the iron rod near a bar magnet and observe if it attracts iron pins
- (2) Place the iron rod near a current carrying wire and observe if it attracts iron pins
- (3) Place the iron rod inside a current carrying solenoid and observe if it attracts iron pins
- (4) None of these.

**72.** Current can be made to flow through a coil without connecting the coil with a battery. Which of the following procedures would be most suited to test this fact ?

- (1) Connect a galvanometer across the ends of the coil and observe if galvanometer shows a deflection, when a bar magnet is placed near the one end of the coil.
- (2) Connect a galvanometer across the ends of the coil and observe if galvanometer shows a deflection, when a bar magnet is placed inside the coil.
- (3) Connect the galvanometer across the ends of the coil and observe if galvanometer shows a deflection, when a bar magnet is moved towards or away from the coil and along the axis of the coil.
- (4) Connect the galvanometer across the ends of the coil and observe if galvanometer shows a deflection, when a bar magnet is moved at right to the axis of the coil.

**73.** Two coil A and B placed close to each other. If current in the coil A is changed, some current will be induced in the coil B. This is because of electromagnetic induction. In this statement :

- (1) Inference is correct but reasoning is not correct
- (2) Inference is incorrect but reasoning is correct
- (3) Inference as well as reasoning are correct
- (4) Neither inference nor reasoning is correct.



**MAGNETIC EFFECTS OF ELECTRIC CURRENT**

ANSWER-KEY															
Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	2	3	1	2	4	3	1	2	3	4	1	3	3	1	4
Que.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	2	1	3	4	4	3	1	3	4	3	4	3	4	3	3
Que.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Ans.	2	4	4	4	1	4	3	4	3	3	4	3	1	3	1
Que.	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	2	4	2	2	1	4	4	4	3	4	4	2	1	4	3
Que.	61	62	63	64	65	66	67	68	69	70	71	72	73		
Ans.	2	3	1	4	3	3	2	3	2	3	3	3	3		



## SOURCES OF ENERGY

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  - 1. NUCLEAR FISSION
  - 2. NUCLEAR FUSION
  - 3. HYDROGEN BOMB
  - 4. THE SOURCE OF SUN'S ENERGY



# SOURCES OF ENERGY

## SOURCES OF ENERGY

We have a wide range of sources of energy such as the sun, the wind, the earth (geothermal), flowing water, coal, gasoline, diesel, natural gas, biogas, etc. at our disposal. We utilize this energy to perform a wide range of activities, i.e. industrial, commercial, household etc.

A source of energy is one which can provide adequate amount of energy in a convenient form over a long period of time.

## CLASSIFICATION OF SOURCES OF ENERGY

### **1. RENEWABLE AND NONRENEWABLE SOURCES OF ENERGY:**

#### **(A) RENEWABLE SOURCES OF EARTH**

Those sources of energy which are being produced continuously in nature and are inexhaustible, are called renewable sources of energy.

**Example:** wood is a renewable source of energy because if trees are cut from the forests for obtaining wood then more trees will grow in the forest in due course of time.

**The renewable sources of energy are :**

**Examples:** Hydroenergy (Energy from flowing water) ; Wind energy ; Solar energy ; Energy from sea (Tidal energy); Sea wave energy and Ocean thermal energy) ; Geothermal energy ; Biomass energy (Energy from bio fuels such as Wood, Bio gas and Alcohol) ; and Hydrogen

#### **(B) NON- RENEWABLE SOURCES OF ENERGY**

Those sources of energy which have accumulated in nature over a very, very long time and cannot be quickly replaced when exhausted are called non - renewable sources of energy.

**Example:** coal is a non - renewable source of energy because coal has accumulated in the earth over a very, very long time and if all the coal gets exhausted, it cannot be produced quickly in nature.

**The non renewable sources of energy are**

**Examples:** Fossil fuels (Coal, Petroleum and natural gas) and Nuclear fuels (such as uranium). Non - renewable sources of energy are dug out from the earth.

### **2. CONVENTIONAL AND NONCONVENTIONAL SOURCES OF ENERGY:**

#### **(A) CONVENTIONAL SOURCES OF ENERGY**

The traditional sources of energy which are familiar to most people are called conventional sources of energy.

The main conventional sources of energy are wood and fossil fuels (like coal, petroleum and natural gas).

The fuels derived from wood, coal and petroleum such as charcoal, coke, coal gas, petrol, diesel, kerosene, fuel oil and liquefied petroleum gas (LPG) are also known as conventional sources of energy.

#### **(B) NON-CONVENTIONAL SOURCES OF ENERGY**

Sources of Energy that we have started using in New ways or Only in Recent times are called alternative sources of energy (or non conventional sources of energy).

**Examples:** Hydroelectric energy, Wind energy, Solar energy, Biomass energy, Energy from the sea (Tidal energy, Sea - wave energy, Ocean thermal energy), and Geothermal energy.



## FUELS

A fuel is a chemical which releases energy when heated with oxygen. The energy may release in the form of heat and light.'

**Examples:** Wood, gas, petrol, kerosene, diesel, coal and animal waste.

**Note:** Fuels are combustible substances.

### (a) Characteristics of a good fuel

- (i) It should have high calorific value.
- (ii) It should have a proper ignition temperature so that it may burn easily.
- (iii) It should leave no residue (or very small amount of residue) or ash after burning.
- (iv) It should burn smoothly i.e. it should have a moderate rate of combustion and burn at a steady rate.
- (v) It should not be more valuable for some other purpose than fuel. For e.g. coke is a good fuel but it is more valuable as a reducing agent in the extraction of metals.
- (vi) It should be cheap and easily available.
- (vii) It should be easy to handle, safe to transport and convenient to store.

### (b) Types of Fuels

There are three types of fuels solid fuels, liquid fuels and gaseous fuels.

**(i) Solid fuels:** The various kinds of solid fuels are wood, charcoal, coke, coal, paraffin and tallow. Wood was the first solid fuel to be used by humans. Paraffin and tallow are used to make candles.

**(ii) Liquid fuels:** Petrol, kerosene, diesel and methanol are some common liquid fuels. Most of the liquid fuels are obtained from petroleum. They leave no solid residue when burnt and can be stored easily.

**(iii) Gaseous fuels:** Natural gas, coal gas, producer gas, water gas and liquefied petroleum gas are some examples of gaseous fuels.

### (c) Fossil Fuels:

Fossil fuels are the remains of the prehistoric animals or plants, buried under the earth, millions of years ago.

Eg. Coal, petroleum and natural gas.

Fossil fuels are formed in the absence of oxygen. The chemical effects of pressure, heat and bacteria convert the buried remains of plants and animals into fossil fuels like coal, petroleum and natural gas.

It was the sunlight of long ago that made plants grow, which were then converted into fossil fuels. Fossil fuels are energy rich compounds of carbon, which were originally made by the plants with the help of sun's energy.

### (d) Calorific value of fuels:

All the fuels produce heat energy on burning. Different fuels produce different amount of heat on burning. The usefulness of a fuel is measured in terms of its calorific value. The amount of heat produced by burning a unit mass of the fuel completely is known as its **calorific value**.

The unit of mass usually taken for measuring the calorific value of a fuel is gram So it can be said that the amount of heat produced by burning 1 gram of a fuel completely is called its calorific value.

For example, when one gram of a carbon fuel (like charcoal) is burned completely, it produces 33000 joules of heat. So the calorific value of charcoal is 33000 Joules per gram or 33000 J/gm. Since joule is a very small unit of heat energy so the calorific value is usually expressed as **kilojoules per gram (KJ/g)**. The SI unit of measuring calorific value is kilojoules per gram.



Of all the common elements, hydrogen has the higher calorific value. So a fuel containing percentage of hydrogen will have a higher calorific value than another fuel which has a lower percentage of hydrogen in it.

Wood is a mixture of carbon compounds called carbohydrates like cellulose ( $C_6H_{10}O_5$ )<sub>n</sub>. Thus, when wood is burnt, only carbon and hydrogen atoms contained in it burn and produce heat. Oxygen atoms do not produce any heat, they only help in the burning process. So due to comparatively lower percentage of carbon and hydrogen in wood, it has a low calorific value.

All the fuels which contain oxygen burn ready but produce less heat energy per unit weight.

The calorific value of some common fuels are given in the table below.

The material which are burnt to produce heat energy are known as **fuels**.

**Examples of fuels are :** Wood, Coal, Cooking gas (LPG), Kerosene, Diesel and Petrol.

The amount of heat produced by burning a unit mass of the fuel completely is known as its calorific value.

The unit of mass usually taken for measuring the calorific value of a fuel is gram.

For example : when one gram of a carbon fuel (like charcoal) is burned completely, it produced about 33000 joules of heat, so the calorific value of charcoal is 33000 joules per gram or 33000 J/g.

The common unit of measuring calorific value is kilojoules per gram (kJ/g.).

### CALORIFIC VALUES (OR HEAT VALUES) OF SOME COMMON FUELS

S.No.	Fuel	Calorific value
1	Dung cakes	6 to 8 kJ/g
2	Wood	17 kJ/g
3	Coal	25 to 30 kJ/g
4	Charcoal	33 kJ/g
5	Alcohol (Ethanol)	30 kJ/g
6	Diesel (and Fuel oil)	45 kJ/g
7	Kerosene Oil	48 kJ/g
8	Petrol	50 kJ/g.
9	Bio gas	35 to 40 kJ/g
10	Natural gas	33 to 50 kJ/g
11	Cooking gas (LPG)	50 kJ/g
12	Methane	55 kJ/g
13	Hydrogen gas	150 kJ/g

Hydrogen gas has the highest calorific value of 150 kilojoules per gram. Thus, because of its high calorific value, hydrogen is an extremely good fuel.

The minimum temperature to which a fuel must be heated so that it may catch fire and start burning is known as its ignition temperature.



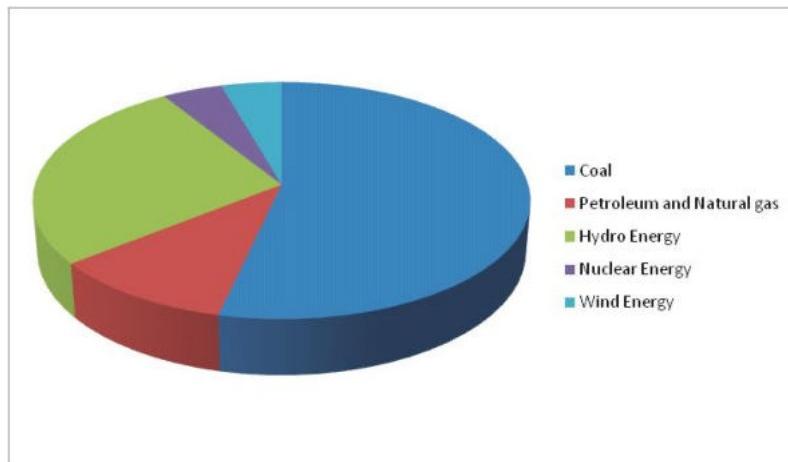
**Newton's Thought**

- Consider the various options we have when we choose a fuel for cooking our food. What are the criteria you would consider when trying to categorise something as a good fuel?
- Would your choice be different if you lived (a) in a forest (b) in a remote mountain village or small island (c) in New Delhi (d) lives five centuries ago. How are the factors different in each case?

**Explanation**

- We can choose wood, kerosene and liquefied petroleum gas (LPG) for cooking our food. A good fuel is one that (a) produces more heat per unit mass or volume on burning (b) does not produce harmful products (c) is easily available (d) should be of low cost.
- (a) Wood is the natural choice as a fuel in a forest.  
 (b) Solar energy, cooking food using solar cookers. Wood or cattle dung are also good choice as fuels in such remote areas.  
 (c) LPG can be used in new Delhi to cook food.  
 (d) Five centuries ago wood, cattle dung or charcoal were the obvious choice.

In all the above cases, the primary factor is the availability of fuel/source of energy. Except in case of New Delhi, the other factors like cost, pollution, efficiency are of secondary importance.

**FOSSIL FUELS**

A natural fuel formed deep under the earth from the pre-historic remains of living organisms (like plants and animals) is called a fossil fuel. Coal, petroleum and natural gas are fossil fuels. Fossil fuels are the major source of energy for generating electricity in power plants.

**HOW FOSSIL FUELS WERE FORMED?**

The plants and animals which died millions of years ago, were gradually buried deep in the earth and got covered with sediments like mud and sand, away from the reach of oxygen of air. In the absence of oxygen, the chemical effects of pressure, heat and bacteria, converted the buried remains of plants and animals into fossil fuels like coal, petroleum and natural gas.

**1. COAL**

Coal is a complex mixture of compounds of carbon, hydrogen and oxygen, and some free carbon. Small amounts of nitrogen and sulphur compounds are also present in coal.

A lot of heat is produced during the burning of coal which makes it a good fuel. Coke is a better fuel than coal because it produces more heat (than an equal mass of coal), and it does not produce smoke while burning.



**❖ USES OF COAL**

- (i) Coal is used as a fuel for heating purposes in homes and in industry.
- (ii) Coal is used as a fuel in thermal power plants for generating electricity.
- (iii) Coal is used to make coke.
- (iv) Coal is used in the manufacture of fuel gases like coal gas.
- (v) Coal is used in the manufacture of petrol and synthetic natural gas.

**2. PETROLEUM**

Petroleum is a dark coloured, viscous, and foul smelling crude oil.

The name petroleum means rock oil.

It is called petroleum because it is found under the crust of earth trapped in rocks.

The crude oil petroleum is a complex mixture of several solid, liquid and gaseous hydrocarbons mixed with water, salt and earth particles.

Petroleum is the crude oil which is a complex mixture of alkane hydrocarbons with water, salt and earth particles. Petroleum cannot be used as a fuel as such.

The fractional distillation of petroleum gives us the following fractions which can be used as **fuels** : Petroleum gas, Petrol (or Gasoline), Diesel, Kerosene and Fuel oil.

Petroleum gas is used as a fuel for domestic heating purposes in the form of liquefied petroleum gas.

Petrol is used as a fuel in motor car, scooters, motor cycles and other light vehicles.

Diesel is used as a fuel for heavy vehicles like buses, trucks, tractors and railway engine. Kerosene oil is used as a household fuel.

Fuel oil is a better fuel than coal because fuel oil burns completely and does not leave any residue.

**3. PETROLEUM GAS (LPG)**

The main constituent of petroleum gas is butane though it also contains smaller amounts of propane and ethane. Petroleum gas is obtained as a by product in oil refineries from the fractional distillation of petroleum.

The petroleum gas which has been liquefied under pressure is called Liquefied petroleum (LPG). Thus, liquefied petroleum gas (or LPG) consists mainly of butane (along with smaller amounts of propane and ethane), which has been liquefied by applying pressure. In other words, the domestic gas cylinders like Indane contain mainly butane.

A domestic gas cylinder contains about 14 kilograms of LPG. A strong smelling substance called ethyl mercaptan ( $C_2H_5SH$ ) is added to LPG cylinders to help in the detection of gas leakage.

**❖ ADVANTAGES OF LPG**

- (i) LPG has a high calorific value, So it is a good fuel.
- (ii) LPG burns with a smokeless flame and so does not cause air pollution.
- (iii) LPG does not produce any poisonous gases on burning.
- (iv) LPG is easy to handle and convenient to store.
- (v) LPG is a very neat and clean domestic fuel.

**❖ DANGERS OF LPG**

LPG is a highly inflammable gas, that is, it catches fire easily. Any leakage of LPG from the gas cylinder, stove or the rubber pipe will form an explosive mixture with air in the kitchen. And on lighting the match stick, an explosion will take place, the whole kitchen will be set on fire and the person working in the kitchen may get burnt.



**◆ PERCAUTIONS OF USING LPG**

- (i) Before lighting a match stick we should make sure that there is no foul smell of the leaking gas in the kitchen, near the gas cylinder or gas stove.
- (ii) We should not use any hot flames like a kerosene lamp, kerosene stove or electric heater near the gas cylinder.
- (iii) We should never use a leaking gas cylinder.
- (iv) We should handle the gas cylinder with care so that its valve does not get damaged.
- (v) The rubber pipe connecting the gas cylinder to gas stove should be checked periodically for any wear and tear.

**4. NATURAL GAS**

Natural gas consists mainly of methane ( $\text{CH}_4$ ) with small quantities of ethane and propane. In fact, natural gas contains upto 95% methane, the remaining being ethane and propane. Natural gas occurs deep under the crust of the earth either alone or alongwith oil above the petroleum deposits. Natural gas is formed under the earth by the decomposition of vegetable matter lying under water. This decomposition is carried out by anaerobic bacteria.

1. Natural gas is used as a domestic and industrial fuel.
2. Natural gas is used as a fuel in thermal power plants for generating electricity.
3. Compressed Natural gas (CNG) is being used increasingly as a fuel in transport vehicles.

**◆ ADVANTAGS OF NATURAL GAS**

- (i) Natural gas being a complete fuel in itself can be used directly for heating purposes in homes and industries.
- (ii) Natural gas is a good fuel because it has a high calorific value of about 50 kJ/g.
- (iii) A great advantage of natural gas is that it can be supplied directly from the gas wells to the homes and factories for burning through a net - work underground pipelines, and this eliminates the need for additional storage and transport.

**◆ POLLUTION CAUSED BY FOSSIL FUELS**

- (i) The burning of fossil fuels produces acidic gases such as sulphur dioxide and nitrogen oxides.
- (ii) The burning of fossil fuels produces large amount of carbon dioxide which goes into air.
- (iii) The burning of fossil fuels (especially coal) produces smoke which pollutes the air.
- (iv) The burning of coal leaves behind a lot of ash.

**◆ CONTROLLING POLLUTION CAUSED BY FOSSIL FUELS**

- (i) The pollution of air caused by burning petroleum fuels (like petrol and diesel). in vehicles can be controlled by fitting the vehicles with catalytic converters.
- (ii) The pollution of air caused by burning coal in thermal power plants and factories can be controlled by washing down the smoke and acidic gases by water in a scrubber.
- (iii) The pollution of air caused by burning coal in thermal power plants and factories can also be controlled by installing electrostatic precipitators in their chimneys.

**Newton's Thought**

Why thermal power plants are set up near the coal fields or oil fields? Which one will you prefer as a fuel for power generation in current scenario, coal or petroleum?

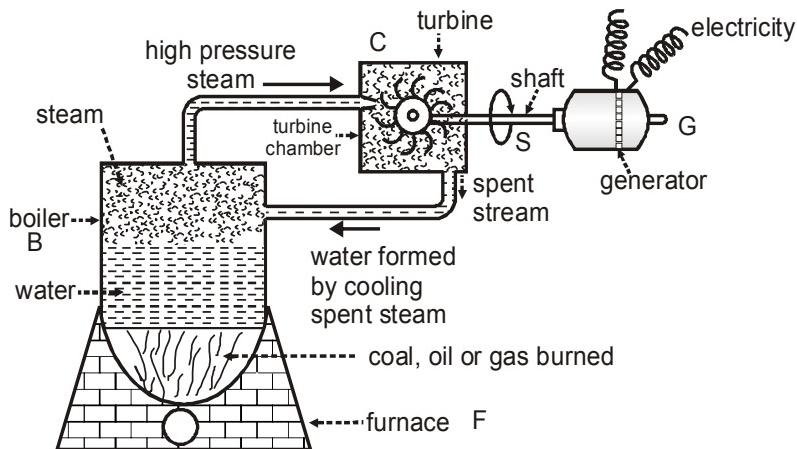
**Explanation**

the transmission of electricity is more efficient than transporting coal or petroleum over the same distance. Therefore, many thermal power plants are set up near coal or oil fields. In current scenario, coal should be preferred because of its larger availability in comparison with petroleum. Thus, using coal as a fuel for power generation produces cheaper electricity in comparison with petroleum.



## THERMAL POWER PLANT

An installation where electricity (or electrical power) is generated is called a power plant. A power plant is also called a power house. A power plant in which the heat required to make steam to drive turbines is obtained by burning fuels is called thermal power plant.



Coal is burned in a furnace F to produce heat. This heat boils the water in a boiler B to form steam. The steam formed from the boiling water builds up pressure. The hot steam at high pressure is introduced into a turbine chamber C having a steam turbine T. The steam passes over the blades of the turbine as a high pressure jet making the turbine rotate. The shaft S of turbine is connected to a generator G. When the turbine rotates, its shaft also rotates and drives the generator. The generator produces electricity. The spent steam coming out of turbine chamber is cooled. On cooling, steam condenses to form water. This water is again sent to the boiler to form fresh steam. This process is repeated again and again. We produce a major part of our electricity by burning fossil fuels.

## HYDROELECTRIC ENERGY

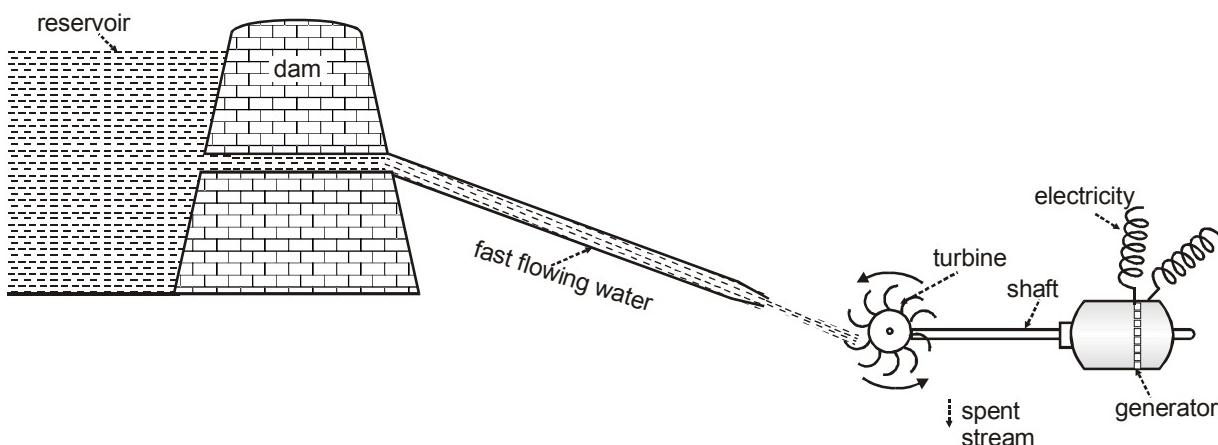
Flowing water possesses kinetic energy. The traditional use of energy of flowing water has been modified by improvements in technology and used to generate electricity.

### **Hydro-power plant (or Hydroelectric power plant) :**

A power plant that produces electricity by using flowing water to rotate a turbine (which drives the generator), is called hydro power plant.

The electricity produced by using the energy of falling water (or flowing water) is called hydroelectricity. A hydro power plant produces electricity.

A high rise dam is built to stop the flowing river water. Due to this, a large lake or reservoir builds up behind the dam. The kinetic energy of the flowing river water is converted into the potential energy of water stored behind the dam.



## SOURCES OF ENERGY

The sluice gate half the height of dam are opened to allow some of the stored water to escape. The water falls down through a large height from the dam, it flows very fast. A high pressure jet of fast flowing water pushes on the blades of turbine with a great force and makes the turbine rotate rapidly. When the turbine rotates, its shaft also rotates and drives the generator. The generator produces electricity.

A hydro power plant converts the potential energy of water stored in the reservoir of a tall dam into electric energy.

### ◆ ADVANTAGES OF GENERATING HYDROELECTRICITY

- (i) The generation of electricity from flowing water does not produce any environmental pollution.
- (ii) Flowing water is a renewable source of electric energy which will never get exhausted.
- (iii) The construction of dams on rivers helps in controlling floods, and in irrigation.

### ◆ DISADVANTAGES OF HYDROELECTRICITY

- (i) Dams built for large hydroelectric plants submerge a large area of land under water & also affects the plants and animals of the region.
- (ii) Large hydroelectric power plants are expensive to build.
- (iii) Not all rivers and not all areas are suitable for hydroelectric power generation.

### ◆ SCOPE OF HYDROELECTRICITY

Hydroelectricity has huge potential worldwide. In India, it is estimated that 145,000 MW of hydroelectricity can be generated. Out of this, by 2006, India had an installed capacity of about 34,000 MW.

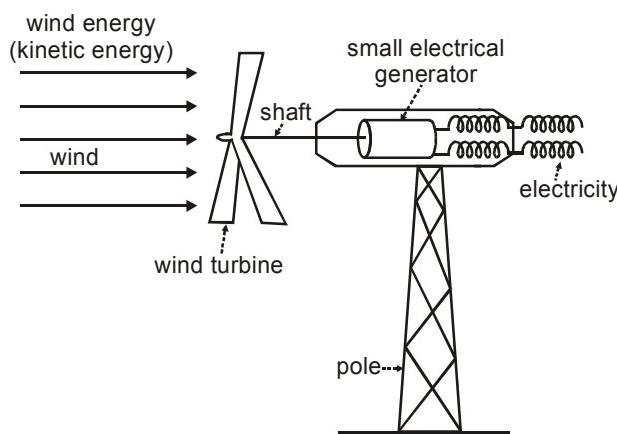
## WIND ENERGY

Moving air is called wind. The wind possesses kinetic energy. It is this kinetic energy of wind which is utilized for doing work. Solar energy is responsible for the blowing of wind.

The traditional use of wind energy has now been modified by the improvement in technology to generate electricity through wind powered generators.

### ◆ WIND GENERATOR

A wind generator which is used to generate electricity by using wind energy. When the fast moving wind strikes the blades of wind turbine, then the wind turbine starts rotating continuously. The shaft of wind turbine is connected to a small generator. When the wind turbine rotates, its shaft also rotates and drives the generator. The generator produces electricity.



An important advantage of using wind energy for generating electricity is that its use does not cause any pollution. Another advantage is that wind energy is a renewable source of energy which will never get exhausted.



**◆ ADVANTAGES OF WIND ENERGY**

- (i) The source of energy (wind) is free.
- (ii) Harnessing wind energy is a pollution-free process, with no smoke, chemicals, etc., being produced.
- (iii) A small wind-electric plant can be set up near a factory to provide pollution-free power for its use.

**◆ LIMITATIONS OF WIND ENERGY**

- (i) Wind energy cannot be harnessed at places where wind does not blow regularly. A wind-electric generator works only on winds of at least 15 km/h.
- (ii) Wind is not a dependable source of energy because sometimes the air is absolutely still and at other times there are storms.
- (iii) It is expensive to set up a wind farm for generating electricity because wind farms need a large area.

**SOLAR ENERGY**

The sun is the source of all energy. The energy obtained from the sun is called solar energy. The solar energy which reaches the earth is absorbed by land and water bodies (like rivers, lakes and ocean) and plants. The solar energy trapped by land and water bodies causes many phenomenon in nature like winds, storms, rain, snowfall and sea waves.

**SOLAR CONSTANT**

The amount of solar energy received per second by one square metre area of the near earth space (exposed perpendicularly to the rays of the sun) at an average distance between the sun and the earth, is called solar constant. The value of solar constant is  $1.4 \text{ kJ/s/m}^2$  or  $1.4 \text{ kW/m}^2$  (because :  $1 \text{ kJ/s} = 1 \text{ kW}$ )

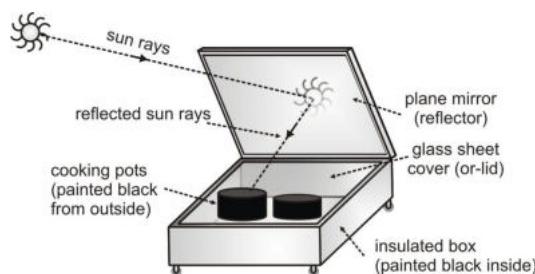
**SOLAR ENERGY DEVICES**

The devices which work by using solar energy (or sun's energy) are : Solar cooker, Solar water heater, and Solar cell. A device which gets heated by using sun's heat energy is called a solar heating device.

All the solar heating devices are designed to such a way that they help in collecting as much sun's heat rays as possible.

**1. SOLAR COOKER**

The solar cooker is a device which is used to cook food by utilising the heat energy radiated by the sun. A solar cooker consists of an insulated metal box or wooden box which is painted all black from inside. There is a thick glass sheet cover over the box and a plane mirror reflector is also attached to the box. The food to be cooked is put in metal containers which are painted black from outside.



When the sun's rays fall on the reflector, the reflector sends them to the top of solar cooker box in the form of a strong beam of sunlight. The sun's heat rays pass through the glass sheet cover and get absorbed by the black inside surface of the cooker box.

In this way, more and more heat rays of the sun get trapped in the box due to which the temperature in the solar cooker box rises to about  $100^\circ\text{C}$  to  $140^\circ\text{C}$  in two to three hours. This heat cooks the food materials kept in the black containers.



## SOURCES OF ENERGY

The important advantages of a solar cooker for cooking food are the following :

- (i) The use of solar cooker for cooking food saves precious fuels like coal, kerosene and LPG.
- (ii) The use of solar cooker does not produce smoke due to which it does not pollute air.
- (iii) When food is cooked in solar cooker, its nutrients do not destroyed. This is because in a solar cooker, food is cooked at a comparatively lower temperature.
- (iv) In a solar cooker, up to four food items can be cooked at the same time.

### **Some of the important limitation of a solar cooker are given below :**

- (i) The solar cooker cannot be used to cook food during night time (because sunshine is not available at that time).
- (ii) If the day sky is covered with clouds, even then solar cooker cannot be used to cook, food.
- (iii) The direction of reflector of solar cooker has to be changed from time to time to keep it facing the sun.
- (iv) The box type solar cooker cannot be used for baking (making chapattis, etc.) or for frying.

### **Newton's Thought**

Why a solar cooker exposed to the bright sunlight gets heated from inside?

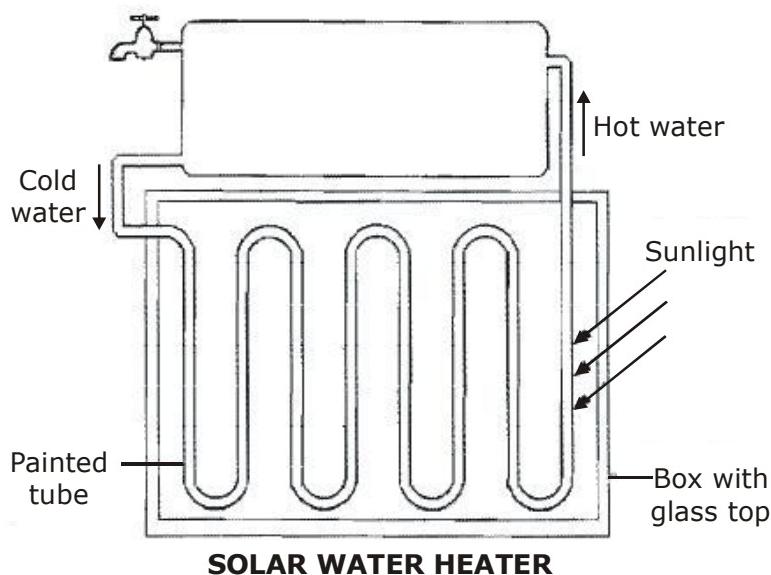
#### **Explanation**

The infrared rays contained in the sunlight are of shorter wavelengths as the temperature of sun is very high (higher the temperature, higher will be the frequency of emitted rays, shorter will be their wavelength). When a solar cooker is exposed to bright sunlight, the glass cover plate of the solar cooker allow these infrared rays to enter inside, which heats up its black painted inner parts. The heated inner part radiate infrared rays of longer wavelength as their temperature is quite low. Glass cover plate does not allow these infrared rays to pass through them. Thus, the heat from inside cannot escape from the box. As a result, the solar cooker gets heated from inside.

## 2.

### **SOLAR WATER HEATER**

Solar energy can be used to heat water. In a solar water heater, sunlight is allowed to fall on a box made of a poor conductor of heat. The glass top of the box lets in sunlight and traps heat. Water enters a tube that is painted black to increase the absorption of heat. It is bent several times to increase its length inside the box. This allows the water flowing through it sufficient time to absorb heat. Hot water collects in the tank of the heater for use.

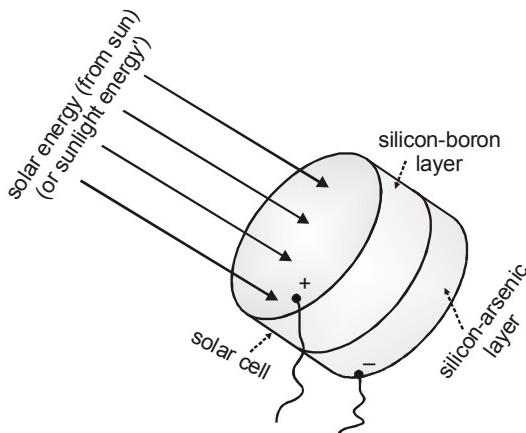


**SOLAR WATER HEATER**



### 3. SOLAR CELL

Solar cells use the energy in sunlight to produce electricity. Thus, solar cell is a device which converts solar energy (or sun's energy) directly into electricity.



A solar cell is usually made from silicon. A simple solar cell consists of sandwich of a 'silicon-boron layer' and a 'silicon-arsenic layer'.

A single solar cell can produce only a small amount of electricity.

The group of solar cells is called a 'solar cell panel' or just 'solar panel'.

The various solar cells in a solar panel are joined together by using connecting wires made of silver metal. This is because silver is the best conductor of electricity.

**The main advantages of solar cells** are that they have no moving parts.

They require almost no maintenance, and work quite satisfactorily without the use of any light focusing device.

#### Advantages of solar cells

- Solar cells are suitable for use in remote areas where electrical power lines have not reached.
- Solar cells require little maintenance and last for a long time.
- After installation, no further cost is involved in generating electricity directly from solar cells.
- Solar cells are environment friendly, as they do not cause any pollution.

**Disadvantage of solar cells** is that they are very expensive.

This is due to the following reasons :

- The special grade silicon needed for making solar cells is expensive
- Silver wire used to interconnect solar cells for making solar panels is expensive, and
- The entire process of making solar cells is still very expensive.



#### USES OF SOLAR CELLS

- Solar cells are used for providing electricity in artificial satellites and space probes.
- Solar cells are used for providing electricity to remote, inaccessible and isolated places where normal electricity transmission lines do not exist.
- Solar cells are used for operating traffic signals, watches, calculators and toys.

### 4.

#### SOLAR PANEL

Although a solar cell provides very little power, a large number of connected solar cells, spread over a large area, can provide sufficient power for many applications. Such an arrangement of solar cells is called a solar panel. The solar cells in a solar panel are connected in such a way that the total potential difference and the total capacity to provide electric current become large.

**Uses of Solar Panels:** The advantage of solar panels is more in areas where the usual energy sources are not available. That is why they are used as the source of electric power in satellites. Solar panels have also been used in unmanned aircraft that fly at high altitudes for long periods, conducting scientific experiments. Experimental solar-powered cars have also been made. In many parts of India, solar panels are being used to charge rechargeable batteries during the day. At night, these batteries provide electric power for lightening, etc. They are also being used for operating traffic lights, water pumps, telephones, TV sets and radio receivers.



**◆ ADVANTAGES OF SOLAR CELLS**

- (a) Solar cells are suitable for use in remote areas where electrical power lines have not reached.
- (b) Solar cells require little maintenance and last for a long time.
- (c) After installation, no further cost is involved in generating electricity directly from solar cells.
- (d) Solar cells are environment friendly, as they do not cause any pollution.

**Newton's Thought**

How can you utilise wood as a fuel in efficient way in villages?

**Explanation**

In villages, wood is burned in traditional chulhas which have poor efficiency of about 8-10%. Also the smoke produced due to incomplete combustion leads to health hazards. These problems are overcome by scientifically designed chulhas, called **smokeless chulhas** which allow better combustion. These chulhas use less fuel and therefore are more efficient. The smoke is removed by a chimney attached to the chulhas which provides a cleaner household and ensures better health for human beings.

**BIO MASS ENERGY**

The dead parts of plants and trees, and the waste material of animals are called biomass. Biomass includes wood, agricultural wastes (crop residues) and cow - dung.

Biomass is a renewable source of energy because it is obtained from plants (or animals) which can be produced again and again.

**◆ THE CASE OF WOOD AND CHARCOAL**

Wood is biomass. The traditional use of wood as a fuel has many disadvantages. For example (i) the burning of wood produces a lot of smoke which pollutes the air, and (ii) the calorific value (or heat value) of wood is low, being only 17 kJ/g. This means that wood produces less heat per unit mass, on burning.

Wood can be converted into a much better fuel called charcoal. Charcoal is mainly carbon (C). Charcoal is a better fuel than wood because

- (i) Charcoal has a higher calorific value than wood.
- (ii) Charcoal does not produce smoke while burning.
- (iii) Charcoal is a compact fuel which is easy to handle and convenient to use.

**◆ THE CASE OF COW DUNG AND BIOGAS**

Cow dung is biomass. It is also known as 'cattle dung' or 'animal dung'. When cow dung cakes are burnt, they produce heat. This heat is used for cooking food, etc. It is, however, not good to burn cow dung directly as a fuel because of the following disadvantages :

- (i) Cow dung contains important elements like nitrogen and phosphorus, which are required by the soil to support crops.
- (ii) Dung cakes produce a lot of smoke on burning which causes air pollution.
- (iii) Dung cake do not burn completely, they produce a lot of ash as residue.
- (iv) Dung cakes have low calorific value.

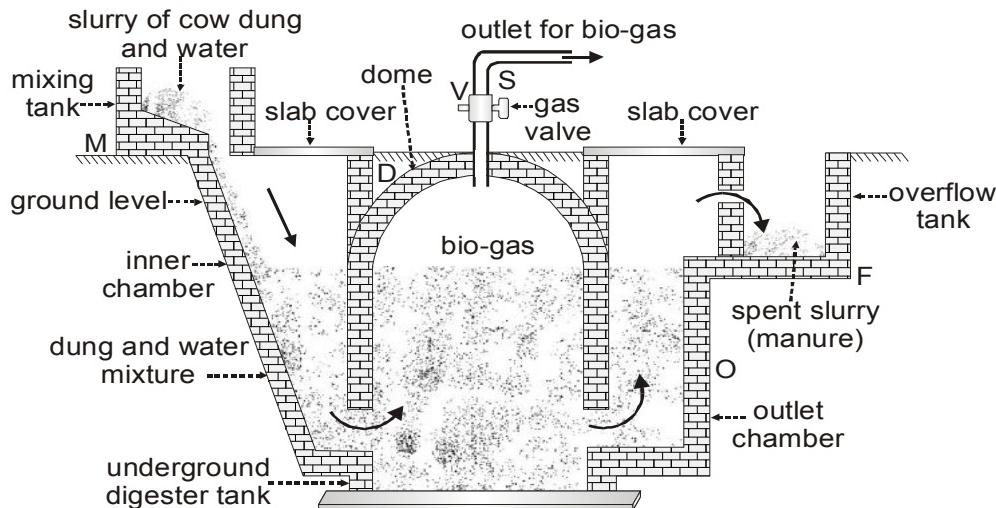
Biogas is a mixture of methane, carbon dioxide, hydrogen and hydrogen sulphide. The major constituent of biogas is methane. Biogas is produced by the anaerobic degradation of animal wastes like cow dung (or plant wastes) in the presence of water.

**◆ BIO GAS PLANT**

A biogas plant consists of a well shaped, underground tank T called digester, which is made of bricks, and has a dome shaped roof D, also made of cement and bricks . The digester is a kind of sealed tank in which there is no air. The dome of the digester tanks acts as a gas holder or storage tank for the biogas. There is a gas out let S at the top of the dome having a valve V. On the left side of the digester tank is a sloping inlet chamber I and on the right side is a rectangular outlet chamber O.



The inlet chamber is connected to a mixing tank M while the outlet chamber is connected to over flow tank F.



Cow dung and water are mixed in equal proportion in the mixing tank M to prepare the slurry. This slurry of dung and water is fed into the digester tank T through the inlet chamber. It takes about 50 to 60 days for the new gas plant to become operative.

During this period, the cow dung undergoes degradation by anaerobic bacteria in the presence of water with the gradual evolution of biogas. This biogas starts collecting in the dome and forces the spent slurry to go into overflow tank F, through the outlet chamber O. From the overflow tank, the spent slurry is removed gradually. The spent dung slurry left after the extraction of biogas, is rich in nitrogen and phosphorus compounds and hence forms a good manure.

The biogas which has collected in the dome of the digester tank is taken out through the outlet S and supplied to village homes through a network of pipes to be used as a cooking gas.

#### ◆ THE IMPORTANT USES OF BIOGAS ARE GIVEN BELOW

- (i) Biogas is used as a fuel for cooking food.
- (ii) Biogas is also used for lighting.
- (iii) Biogas is used as a fuel to run engines.
- (iv) Biogas is used for generating electricity.

#### ◆ ADVANTAGE OF BIOGAS

- (i) A biogas plant is quite simple and can be easily built in rural areas.
- (ii) Biogas is an excellent, clean fuel that burns without producing ash and smoke.
- (iii) The spent slurry is good manure.
- (iv) Biogas plants are a safe and useful way of waste disposal.
- (v) Use of biogas in rural areas leads to saving of firewood, and reduces deforestation.

## ENERGY FROM THE SEA

The energy from the sea can be obtained mainly in three forms :

1. Tidal energy
2. Wave energy, and
3. Ocean thermal energy

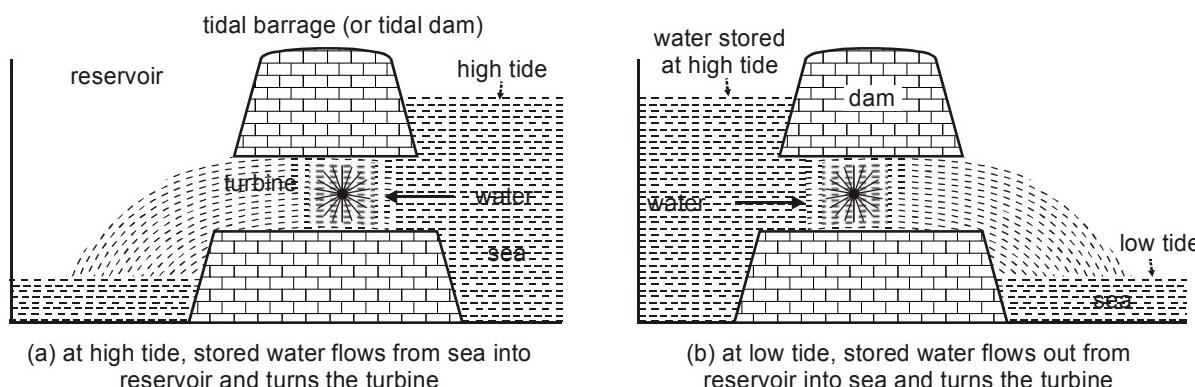
#### 1. TIDAL ENERGY :

The rise of sea water due to gravitational pull of the moon is called high tide whereas the fall of sea water is called low tide. The tidal energy can be harnessed by constructing a tidal barrage or tidal dam across a narrow opening to the sea.



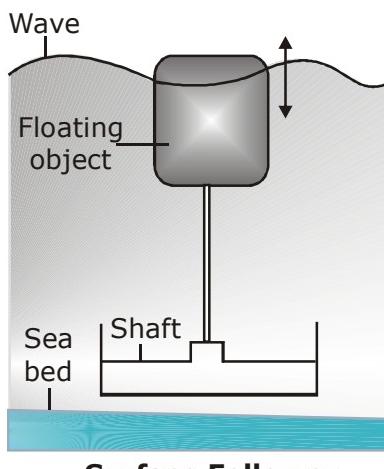
## SOURCES OF ENERGY

During high tide, when the level of water in the sea is high, sea water flows into the reservoir of the barrage and turns the turbines. The turbines then turn the generators to produce electricity. And during the low tide, when the level of sea water is low, the sea water stored in the barrage reservoir is allowed to flow out into the sea. This flowing water also turns the turbines and generates electricity.



## 2. WAVE ENERGY :

Wave energy here means sea waves energy. Due to the blowing of wind on the surface of sea, very fast sea waves move on its surface. Due to their high speed, sea waves have a lot of kinetic energy in them. The energy of moving sea waves can be used to generate electricity. A wide variety of devices have been developed to trap sea wave energy to turn turbines and drive generators for the production of electricity.

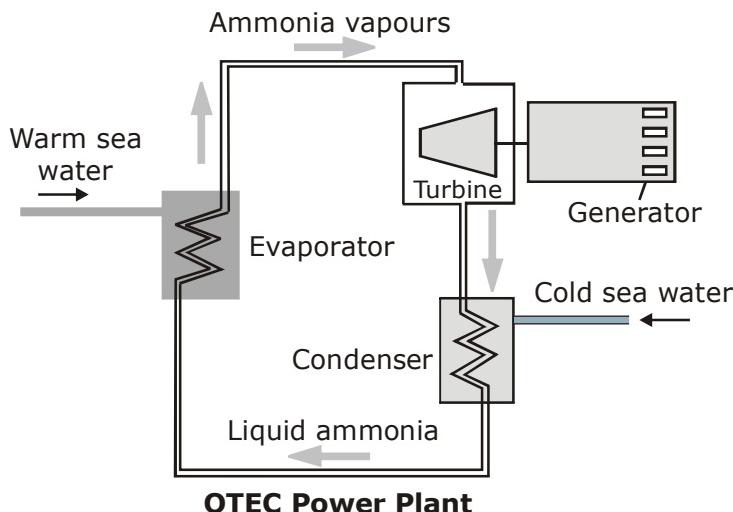


## 3. OCEAN THERMAL ENERGY CONVERSION (OTEC):

Solar energy falling on the surface of the ocean warms it. The water at the surface of the ocean is warmer than the water deep below. Generally, the difference in temperature is about  $20^{\circ}\text{C}$  between the surface water and the water at a depth of 1 km. This temperature difference can be used to operate an ocean thermal energy conversion (OTEC) plant. Clearly, the ultimate source of the stored thermal energy of the ocean is the sun.

In one system for OTEC, a fluid with low boiling point such as ammonia or chlorofluorocarbon (CFC) is used as the 'working fluid'. Warm sea water is used to vaporize liquid ammonia in an evaporator. The expanding vapours of ammonia turn a turbine connected to a generator. Then the vapours go to a condenser. There, cold sea water, pumped up from the deep, is used to liquefy the ammonia. This ammonia is reused, and the cycle goes on.

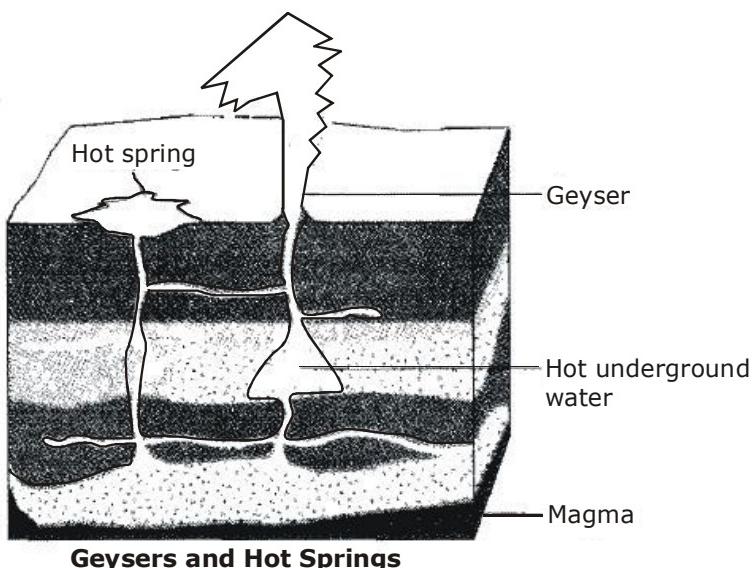




## GEOTHERMAL ENERGY

'Geo' means earth and thermal means heat. Thus, geothermal energy is the heat energy from hot rocks present inside the earth. Geothermal energy is one of the few sources of energy that do not come directly or indirectly from solar energy (or sun's energy)

At some places in the world, the rocks at some depth below the surface of the earth are very, very hot. This heat comes from the fission of radioactive materials which are naturally present in these rocks. The places where very hot rocks occur at some depth below the surface of earth geothermal energy. Energy does not cause any pollution.



### Some of the disadvantages of geothermal energy are as follows :

Geothermal energy is not available everywhere it is available only in those areas where there are hot rocks near the earth's surface.

## NUCLEAR ENERGY

The energy released during a nuclear reaction is called nuclear energy. Nuclear energy can be obtained by two types of nuclear reactions

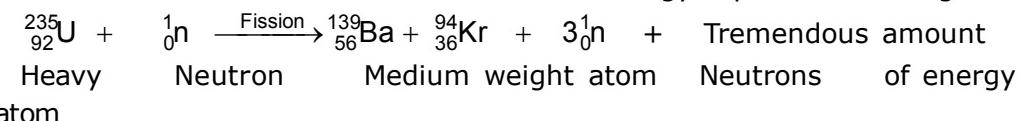
1. Nuclear fission and
2. Nuclear fusion

The nuclear energy is released mainly in the form of heat.



## 1. NUCLEAR FISSION

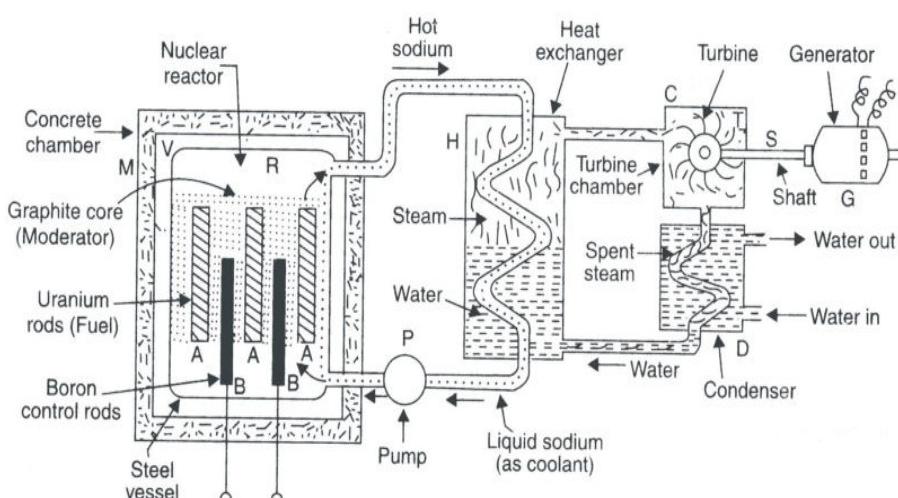
The process in which the heavy nucleus of a radioactive atom (such as uranium, plutonium or thorium) splits up into smaller nuclei when bombarded with low energy neutrons, is called nuclear fission. When uranium - 235 atoms are bombarded with slow moving neutrons, the heavy uranium nucleus breaks up to produce two medium – weight atoms, barium – 139 and krypton – 94. with the emission of 3 neutrons. A tremendous amount of energy is produced during the fission of uranium.



The energy produced during nuclear fission reactions is used for generating electricity at nuclear power plants.

### Nuclear Power Plant :

A power plant in which the heat required to make steam and turn turbines (to drive generators for making electricity) is obtained by nuclear reaction, is called a nuclear power plant. Most of the nuclear power plants use uranium 235 as fuel in produce heat.



In a nuclear power plant, the fission of nuclear fuel uranium 235 is carried out in a steel pressure vessels V of reactor R (Reaction is a kind of nuclear furnace).

The enriched uranium 235 rods marked A are inserted in a core made of graphite blocks inside the reactor. Graphite is called a moderator.

It slows down the speed of neutrons to make them fit for causing fission.

In between the uranium rods are inserted boron rods B. Boron rods are called control rods because they absorb excess neutrons and prevent the fission reaction from going out of control.

The reactor is enclosed in a concrete chamber M having thick walls to absorb the nuclear radiations. so as to protect the outside world from the dangerous nuclear radiation.

Liquid sodium is used as a coolant to transfer the heat produced in the reactor by fission to heat exchanger for converting water into steam.

The controlled fission of uranium 235 in the nuclear reactor produces a lot of heat energy. Liquid sodium is pumped continuously through the pipes embedded in reactor by using a pump P.

Sodium absorbs the heat produced in the reactor. This extremely hot sodium is then passed into the coil of the heat exchanger containing water.

Water absorbs heat from hot sodium and boils to form steam. The hot steam at high pressure is introduced into a turbine chamber C having a turbine T. The pressure of steam makes the turbine rotate.

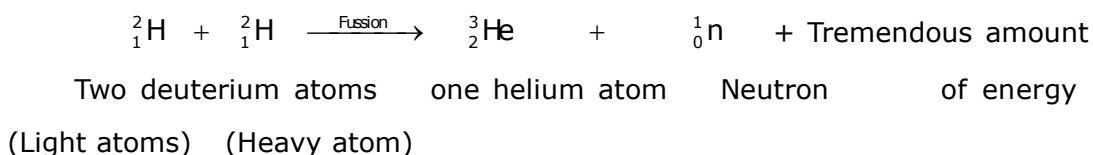
The shaft S of turbine is connected to a generator G. When the turbine rotates, its shaft also rotates and drives the generator. The generator produces electricity.



## 2. NUCLEAR FUSION

The word fusion means to joint or to combine. The process in which two nuclei of light elements like that of hydrogen combine to form a heavy nucleus (like that of helium) is called nuclear fusion. A tremendous amount of energy is produced during the fusion process.

When deuterium atoms (heavy hydrogen atoms of mass number 2) are heated to an extremely high temperature under extremely high pressure, then two deuterium nuclei combine together to form a heavy nucleus of helium, and a neutron is emitted. A tremendous amount of energy is liberated in this fusion reaction.



A fusion process is just the opposite of fission process. The energy produced in nuclear fusion reaction is, however, much more than that produced in a nuclear fission reaction.

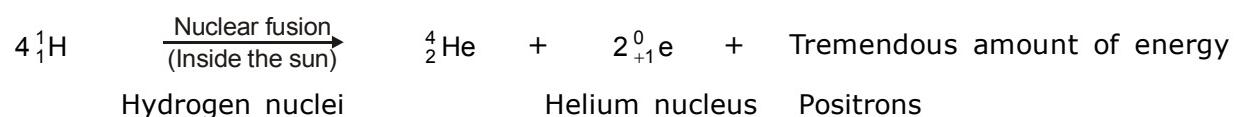
## 3. HYDROGEN BOMB

The hydrogen bomb consists of heavy isotopes of hydrogen called deuterium ( ${}^2\text{H}$ ) and tritium ( ${}^3\text{H}$ ) alongwith an element lithium - 6 ( ${}^6\text{Li}$ ). The detonation (or explosion) of hydrogen bomb is done by using an atom bomb (based on the fission of uranium - 235 or plutonium - 239) When the atom is exploded, then its fission reaction produces a lot of heat. This heat raises the temperature of deuterium and tritium to  $107^\circ\text{C}$  in a few microseconds. At this temperature, fusion reactions of deuterium and tritium take place producing a tremendous amount of energy. This explodes the hydrogen bomb releasing an enormous amount of energy in a very short time. This energy causes destruction of life and property.

## 4. THE SOURCE OF SUN'S ENERGY

The sun is huge mass of hydrogen gas and the temperature in it is extremely high. The sun which gives us heat and light, derives its energy from the fusion of hydrogen nuclei into helium nuclei, which is going on inside it. all the time.

The main nuclear fusion reaction taking place in the sun which releases a tremendous amount of energy is the fusion of 4 hydrogen atom nuclei to form a bigger nucleus of helium atom. That is:



Nuclear fusion reactions of hydrogen are the source of sun's energy.

An **advantage** of nuclear fusion reactions over nuclear fission for producing electricity is that the amount of energy released in a fusion reaction is much more than that liberated in a fission reaction.

**Disadvantage** of a nuclear fusion reactions is that it has not been possible to have a controlled fusion reactions so far, and to safety use the enormous heat produced during this reaction for the production of electricity.



## SOLVED PROBLEMS

**Ex.1** What is the alternative name for renewable sources of energy?

**Sol.** The following are the characteristics of a good source of energy:

- (i) It should give an adequate amount of net energy.
- (ii) It must be convenient to use so as to give energy at a steady rate.
- (iii) It must be easy to store and transport.

**Ex.2** What are the types of energy sources?

**Sol.** Energy sources can be classified as :

**(i) Non-renewable sources :**

Fossil fuels like coal, petroleum and natural gas are non-renewable energy sources. These are produced over millions of years due to slow changes and under special circumstances. These are not continuous processes and further it is not becoming possible to discover their new deposits. With the present rate of consumption, it is estimated that known deposits of petroleum in our country will be exhausted in another 200 years and that of coal may last for another 250 years.

**(ii) Renewable sources :**

The energy derived from flowing water, wind, tides, ocean waves and biogas are the Renewable sources. These sources can be harnessed into energy so long as the earth derives its heat and light from the sun or so long as the present solar system exists. Nuclear energy and geothermal energy is also likely to be available for a much longer time. Wood is another renewable source of energy. Though it takes almost 15 years for a tree to mature, this and nuclear energy are also classified as renewable sources.

**OR**

**(i) Conventional sources of energy :**

There are the sources of energy that we have often been using for a long time. For example, wood and fossil fuels like coal, petroleum have been common sources of heat energy. The energy of flowing water and wind are also used for limited activities.

**(ii) Non-conventional sources of energy :**

With increasing demand recently energy from sun, sea waves and earth is also tapped.

**Ex.3** What type of energy transformation takes place during winding of spring of a clock?

**Sol.** Energy to run a cycle : Energy of muscles

Energy to run a car : Chemical energy of petrol or diesel

Energy to cook food : Chemical energy of gas or Kerosene

Energy to work on : Electrical energy obtained from say potential energy of water, electrical appliances chemical energy of fuels etc.

**Ex.4** Give an example of the use of wind energy to perform mechanical work by early man.

**Sol.** **Advantages of using fossil fuels :** Petroleum and natural gas.

- (i) These leave no residue on burning.
- (ii) They have reasonably low ignition temperature and thus burn easily.
- (iii) The combustion is almost complete and thus no smoke is left on burning.
- (iv) Calorific value is higher than other usable fuels.

**Disadvantages of using fossil fuels:**

- (i) The end product is carbon dioxide which causes green house effect.
- (ii) When petrol is burnt, harmful substances like unburnt hydrocarbons, carbon monoxide, oxides of nitrogen, sulphur are produced. These cause acid rain and thus soil and water pollution give innumerable problems to health.



## SOURCES OF ENERGY

**Ex.5** In what forms energy is utilized in our homes?

**Sol.** The sun's energy is useful to us because :

- (i) it regulates the flow of wind and water cycles on the earth.
- (ii) it helps the plants to grow which in turn provide food to us.
- (iii) it can be used for heating and cooking purposes.

**Ex.6** What is the parameter known as which gives the amount of light received per square metre per second from the sun ?

**Sol.** Geothermal energy and nuclear energy are not related to the energy of the sun. Nuclear energy is derived from radioactive substances found under the earth. Geothermal energy is derived from the hot spots beneath the earth. Thus their sources are a results of the formation of earth and not influenced by the energy of the sun falling on earth.

**Ex.7** A body kept in a dark room is exposed to radiations emitted by a hot iron. will it be visible to us ?

**Sol.** The change of one form of energy into another form(or forms) of energy is called transformation of energy. The different forms of energy are : potential energy, kinetic energy, chemical energy, heat energy, solar energy, electrical energy and light energy. When a body from a height falls to the ground, its potential energy is converted into kinetic energy and then into heat energy.

**Ex.8** Is the heat of fire a source of energy ?

**Sol.** Petroleum obtained by drilling holes in the earth's crust is a crude oil. This is brown black liquid and contains a mixture of various substances besides water and earthy particles. It cannot be put to use as such. It is, therefore, separated into constituents which are used for specific purposes. The process of separation is called refining of petroleum and is done by a technique known as fractional distillation.

**Ex.9** Mention any two sources of energy used by ancient man around the 17<sup>th</sup> century for doing his daily work.

**Sol.** Some of the conventional sources of energy have poor efficiency and produce a lot of smoke due to incomplete combustion. For example,

**Wood** : As is well-known, wood is burnt in traditional chulhas. It has poor efficiency because only about 8% of the wood is utilized as fuel. Besides incomplete burning ( combustion), it produces gases like carbon monoxide which are dangerous for health.

**Animal dung** : Animal dung mixed with mud and made in the form of cakes and dried are burnt in many parts of country for use for domestic purposes. As dung cakes are burnt inefficiently in the conventional manner, it produces a lot of smoke. Further as animal dung contains useful nutrients for soil, the burning of animal dung causes considerable wastage of useful elements, besides producing air pollution.

**Agricultural wastes** : Agricultural wastes like sugarcane (from which juice has been extracted) are burnt for use in industries. This and other animal and plant wastes could be more profitably used in biogas plants.

**Ex.10** What is the form of energy possessed by moving wind or water?

**Sol.** The use of cow-dung in biogas plants to produce biogas as fuel is preferred over the use of cow-dung directly because of the following reasons:

- (i) Cow-dung contains important nutrients like nitrogen and phosphorus, which are very useful for crops. Now, when the cow-dung is used to prepare biogas, then the residue left behind is still rich in nutrients and can be used as manure, But if the cow-dung is burnt in the form of dried cow-dung cakes, then the nutrient contained therein are destroyed and hence cannot be used as manure.
- (ii) The fuel (biogas) obtained by the use of cow-dung in biogas plants does not produce any smoke on burning and does not cause air-pollution.
- (iii) The fuel obtained by the use of cow-dung biogas plants is a clean fuel and does not leave behind any ash or residue. On the other hand cow-dung cakes do not burn completely and leave behind a lot of ash.



## NCERT QUESTIONS WITH SOLUTIONS

**Q.1** What is a good source of energy?

**Ans.** A good source of energy

- (i) should be capable of doing large amount of work per unit mass or volume.
- (ii) should be easily accessible i.e., it should be convenient to use
- (iii) should be easy to transport and store.
- (iv) should be capable of delivering desired quantity of energy at a steady rate over a long period of time.
- (v) should be economical.

**Q.2** What is a good fuel?

**Ans.** (i) it should have a high calorific value (calorific value is defined as the number of heat units produced when unit mass of fuel is burnt). thus, a good fuel should liberate more heat per unit mass.

- (ii) It should have low moisture content.
- (iii) It should have low non-combustible matter like ash, etc. that is, it should leave low ash and other residual matter after combustion.
- (iv) Its products of combustion should not be harmful. An Ideal fuel should not produce any type of harmful products/gases which create air pollution, water pollution, and harmful effects to the human body.
- (v) It should have moderate ignition temperature. Low ignition temperature may cause fire hazards, whereas high ignition temperature may causes difficulty in combustion.
- (vi) It should be easy to store and transport.
- (vii) It should have moderate rate of combustion and its combustion should be controllable.
- (viii) It should be readily available at low cost.

**Q.3** If could use any source of energy for heating your food, which one would you use and why?

**Ans.** We would use a microwave oven for heating the food as it heats it uniformly and cleanly without loss in its nutritional value. Also, we can use solar cooker if bright sunlight is available because the nutrients are not lost during heating in solar cooker.

**Q.4** What are the disadvantages of fossil fuels?

**Ans.** Fossil fuels (coal, petroleum and natural gas) have the following disadvantages:

- (i) The fossil fuels are non-renewable sources of energy, if we continue to consume these sources at alarming rates, we would soon-run out of energy.
- (ii) There are no such alternate sources of energy developed till today which can replace fossil fuels. Thus, large dependency on fossil fuels for most of our energy requirements may create problem in future.
- (iii) Air pollution is caused by burning fossil fuels.
- (iv) Carbon-dioxide produced by burning these fuels contribute to greenhouse effect.



**Q.5** Why are we looking at alternate sources of energy?

**Ans.** Fossils fuels were formed due to extraordinary circumstances that took place millions of years ago. No new reservoirs of these fuels are being formed due to the absence of these circumstances. Thus, they are non-renewable sources of energy. If we continue to use these sources at the present rate, we would soon be deprived of these sources. That is why, we are looking for alternate sources of energy.

**Q.6** How has the traditional use of wind and water energy been modified for our convenience?

**Ans.** The traditional use of wind energy has been modified by using windmills (or wind turbines) and that of water by constructing hydro power plants.

**Q.7** What kind of mirror - concave, convex or plane would be best suited for use in a solar cooker? Why?

**Ans.** A concave mirror is best suited for use in a solar cooker. This is because a concave mirror concentrates solar energy from over a large area into a small area (at its focus). As a result, high temperatures can be achieved. Such a mirror is called solar concentrator.

**Q.8** What are the limitations of energy that can be obtained from the oceans?

**Ans.** The energy obtained from the oceans is

- (i) tidal energy, for which very few suitable sites are available for construction of dams and the generation is intermittent and not very large.
- (ii) sea waves energy, where power output is variable and the currently available technologies are quite expensive.
- (iii) ocean thermal energy, where the conversion efficiency is quite low but a lot of capital investment is required.

**Q.9** What is geothermal energy?

**Ans.** The heat energy inside the earth's crust is known as geothermal energy. The geological changes in some regions push the hot magma upwards which gets collected at some depth below the surface of earth. Such places are called hot spots. These hot spots serve as a source of heat energy (or geothermal energy). The geothermal energy is utilized to convert water into steam which rotates a steam turbine.

**Q.10** What are the advantages of nuclear energy?

- (i) The mass of nuclear fuel like uranium-235 required is extremely small as compared to a fossil fuel to produce the same amount of energy.
- (ii) In a nuclear power plant, the nuclear fuel supplies energy over a long period of time.

**Q.11** Can any source of energy be pollution-free? Why or why not?

**Ans.** No source of energy is totally pollution free, only the degree and the manner of pollution varies. For example, solar cells seem to be non-polluting but environmental pollution is caused in the manufacturing of solar cells.



**Q.12** Hydrogen has been used as a rocket fuel. Would you consider it a cleaner fuel than CNG? Why or why not?

**Ans.** Hydrogen is a cleaner fuel than CNG. This is because it produces water on burning whereas CNG on burning produces CO<sub>2</sub> and CO.

**Q.13** Name two energy sources that you would consider to be renewable. Give reasons for your choices.

**Ans.** (i) Water energy (hydro-energy) water on Earth can be used again and again to generate hydro energy as it is stored again and again in dams due to the water cycle that exists in nature.

(ii) biomass energy, biomass can be managed by replacing the trees that have been cut down for fire-wood, cattle dung will be available as long as life exist on Earth. Thus, we can get a constant supply of energy at a practically usable rate.

**Q.14** Give the names of two energy sources that you would consider to be exhaustible. Give reasons for your choices.

Both these sources are present only in limited amounts and will be exhausted soon if we continue to use them at the present rate. These sources were formed over millions of years under special circumstances.

**Q.15** A solar water heater cannot be used to get hot water on



**Ans.** Option (b) is correct. On cloudy day, heat radiations coming from the Sun do not reach the solar water heater.

**Q.16** Which of the following is not an example of bio-mass energy source?



**Ans.** Option (c) is correct.

**Q.17** Most of the sources of energy we use represent stored solar energy. Which of the following is not ultimately derived from the Sun's energy?



**Ans.** Option (a) is correct.

**Q.18** Compare and contrast fossil fuels and the Sun as sources of energy.

**Ans.** (i) The reserves of fossil fuels are limited i.e., exhaustible and they have high cost. But, solar energy is available in abundance. i.e. it is inexhaustible and that too without any cost.

(ii) Fossils fuels cause air pollution on burning whereas solar energy is pollution free.

(iii) Fossil fuels can provide energy at any required time whereas solar energy is not available every time. For example, on a cloudy day solar energy is not available.



**Q.19** Compare and contrast bio-mass and hydroelectricity as sources of energy.

- Ans.**
- (i) Bio-mass is a renewable source of energy only if we plant trees in a planned manner while hydro-electricity can be renewable by the natural water cycle.
  - (ii) The energy from bio-mass can be obtained by using a chullah or a gobar gas plant which is less costly as compared to hydro-electricity which requires high capital in the construction of dams on rivers and the hydro power plant.
  - (iii) Bio-mass provides pollution-free energy only when converted into biogas whereas hydroelectricity is totally pollution-free.

**Q.20** On what basis would you classify energy sources as

- (a) renewable and non-renewable ?
- (b) exhaustible and inexhaustible? Are the option given in (a) and (b) the same?

- Ans.**
- (a) Renewable sources of energy are those which (i) can be replaced as we use them and (ii) can be used to produce energy again and again. Non-renewable sources of energy are those which cannot be replaced once these are used.
  - (b) Exhaustible sources of energy are those whose supply is limited, e.g., coal, petroleum and natural gas. Inexhaustible sources of energy are those whose energy supply is unlimited e.g., water energy, wind energy, etc.

Renewable sources of energy are inexhaustible whereas non-renewable sources of energy are exhaustible with some exceptions. For example, biomass is a renewable source of energy only if we plant trees in a planned manner.

**Q.21** What are the environmental consequences of the increasing demand for energy? What steps would you suggest to reduce energy consumption ?

- Ans.**
- (i) Burning of fossil fuels to meet increasing demand for energy causes air-pollution.
  - (ii) Construction of dams on rivers to generate hydro-electricity destroys large ecosystems which get submerged under water in the dams. Large amounts of methane (which is a greenhouse gas) is produced when submerged vegetation rots under anaerobic conditions.

In order to reduce energy consumption (i) fossil fuels should be used with caution to get their maximum benefit (ii) energy efficient devices such as pressure cookers, compact fluorescent lamps (CFLs) etc. should be used (iii) the devices/machines used for energy conversion should be maintained or repaired regularly in order to keep them efficient (iii) we should use electricity or any other source of energy judiciously as 'energy saved is energy produced'.



## **EXERCISE – I**

# **BOARD PROBLEMS**

- |  |  |
|--|--|
| <b>Q.1</b> What is energy ?  | <b>Q.18</b> What fraction of solar energy reaches the earth's surface ?                                |
| <b>Q.2</b> What is a source of energy ?  | <b>Q.19</b> What is the value of solar constant on earth ?   |
| <b>Q.3</b> What is a good source of energy ?   | <b>Q.20</b> What is the age of the sun ?   |
| <b>Q.4</b> What is a fuel ?  | <b>Q.21</b> Name some devices that can harness solar energy  |
| <b>Q.5</b> What are fossil fuels ?   | <b>Q.22</b> Name one liquid and one gaseous fossil fuel ?  |
| <b>Q.6</b> What is biomass ?   | <b>Q.23</b> Name the process that produces such a large amount of energy in the sun ?                  |
| <b>Q.7</b> What does Bio-gas consist of ?  | <b>Q.24</b> What is renewable source of energy ?   |
| <b>Q.8</b> What are conventional sources of energy   | <b>Q.25</b> What is non - renewable source of energy   |
| <b>Q.9</b> What are alternative or non-conventional sources of energy ?  | <b>Q.26</b> Name a device used to harness wind energy ?  |
| <b>Q.10</b> Which is the ultimate source of energy   | <b>Q.27</b> What is wind energy farm ?   |
| <b>Q.11</b> What is geothermal energy ?  | <b>Q.28</b> What raw materials can be used in a Bio-gas plant to produce Bio-gas ?                     |
| <b>Q.12</b> Name the renewable sources of energy   | <b>Q.29</b> What is the use of the slurry left behind in the Bio-gas plant ?                           |
| <b>Q.13</b> Name some non-renewable sources of energy?   | <b>Q.30</b> Name the places where nuclear reactors are located in India ?                              |
| <b>Q.14</b> Name any two materials that are used for making solar cells ?                                      | <b>Q.31</b> How much energy need of our country and the world is being fulfilled by the Nuclear power. |
| <b>Q.15</b> Name some gadgets where solar cells are used   | <b>Q.32</b> Why are fossil fuels classified as non renewable sources of energy ?                       |
| <b>Q.16</b> What is the minimum wind velocity required for obtaining electric power with a wind mill generator |  |
| <b>Q.17</b> What is the range of temperature that can be obtained in a box type solar cooker                   |  |



- Q.33** What is the principle of solar cookers ? Name two types of solar cookers.
- Q.34** What is the output of a solar cell ?
- Q.35** Name the different constituents of biogas ?
- Q.36** How does a solar panel light up a bulb at night when there is no solar energy
- Q.37** Why is biogas called a clean fuel ?
- Q.38** Give reasons why hydrogen can not be used as a domestic fuel ?
- Q.39** Name the commonly used forms of energy ?
- Q.40** What are the different types of energies obtained from the sea ?
- Q.41** What are the disadvantages of using cooker
- Q.42** Describe a simple activity to demonstrate the working of a turbine generator, how does it product electricity ?
- Q.43** Explain the working of a hydroelectric power plant to produce electricity?
- Q.44** Describe how a solar cell is fabricated. Name two elements used for fabricating it. What is solar cell panel ?
- Q.45** Draw a diagram and explain the construction and working of a box type solar cooker.
- Q.46** Write 3 advantages of nuclear energy.
- Q.47** Name three forms in which energy from ocean is made available for use. What are OTEC power plants ? How do they operate.
- Q.48** (i) Name the four gases commonly present in bio-gas.  
(ii) List two advantages of using bio-gas fossil fuels.
- Q.49** What are disadvantages of Constructing dams/ producing electricity by Hydropower plants.
- Q.50** Explain the structure and working of a fixed dome biogas plant?
- Q.51** (a) What is a nuclear energy ?  
(b) What are the main hazards of nuclear power generation ?



**EXERCISE – II****NTSE /OLYMPIAD /FOUNDATION PROBLEMS**

- Q.1** Which of the following is a renewable source of energy?  
 (A) Coal                    (B) Natural gas  
 (C) Wood                  (D) Petroleum
- Q.2** The purpose of the glass cover on top of a box-type solar cooker is to  
 (A) allow one to see the food being cooked  
 (B) allow more sunlight into the box  
 (C) prevent dust from entering the box  
 (D) reduce heat loss by radiation
- Q.3** A solar panel is made by combining a large number of  
 (A) solar cookers  
 (B) solar cells  
 (C) solar water heaters  
 (D) solar concentrators
- Q.4** To work properly, wind-electric generators need wind speeds of at least about  
 (A) 1.5 km/h              (B) 15 km/h  
 (C) 150 km/h             (D) 1500 km/h
- Q.5** The site of a hydroelectric plant should be chosen carefully because it  
 (A) produces a large amount of carbon monoxide and carbon dioxide  
 (B) produces a large amount of electricity  
 (C) affects the organisms of the region  
 (D) is expensive
- Q.6** Electricity from the ocean can be generated based on utilizing  
 (A) kinetic energy of the waves but not stored thermal energy  
 (B) stored thermal energy but not kinetic energy of the waves  
 (C) kinetic energy of the waves as well as stored thermal energy  
 (D) neither kinetic energy of the waves nor stored thermal energy
- Q.7** Which energy is not derived from the sun?  
 (A) Nuclear energy  
 (B) Wind energy  
 (C) Biomass energy  
 (D) Ocean-wave energy
- Q.8** Which of the following is not biomass?  
 (A) Sun                    (B) Rice husk  
 (C) Wood                 (D) Cattle dung
- Q.9** The condition for producing biogas is  
 (A) air but not water  
 (B) water but not air  
 (C) air and water  
 (D) neither air nor water
- Q.10** Geothermal energy is feasible in regions that  
 (A) are near the sea  
 (B) have thermal plants  
 (C) have coal mines  
 (D) are over hot spots in the crust
- Q.11** A solar water heater cannot be used to get hot water on  
 (A) a sunny day.  
 (B) a cloudy day.  
 (C) a hot day.  
 (D) a windy day.
- Q.12** Which of the following is not an example of a bio-mass energy source?  
 (A) wood  
 (B) gobar-gas  
 (C) nuclear energy  
 (D) coal



## **Answers**

- |            |   |            |   |            |   |            |   |
|------------|---|------------|---|------------|---|------------|---|
| <b>1.</b>  | C | <b>2.</b>  | D | <b>3.</b>  | B | <b>4.</b>  | B |
| <b>5.</b>  | C | <b>6.</b>  | C | <b>7.</b>  | A | <b>8.</b>  | A |
| <b>9.</b>  | B | <b>10.</b> | D | <b>11.</b> | B | <b>12.</b> | C |
| <b>13.</b> | C | <b>14.</b> | C | <b>15.</b> | B | <b>16.</b> | A |
| <b>17.</b> | C | <b>18.</b> | C | <b>19.</b> | C | <b>20.</b> | A |
| <b>21.</b> | A |            |   |            |   |            |   |



**EXERCISE – III**

**FOR SCHOOL EXAM.**

1. What kind of gases are released while burning fossil fuels?
2. List out the different power plants from which we get electrical energy?
3. What is the major source of energy for the sun?
4. What nuclear reaction takes place in the sun?
5. Draw the schematic picture of a solar cooker?
6. What is the use of the plane mirror of a box type of solar cooker?
7. Which type of solar spectrum is trapped in the solar cooker?
8. What is a solar cell?
9. What are the uses of solar cells?
10. What are the different forms of energies available from the oceans?
11. What are hot spots?
12. What are the different type of nuclear reactions?
13. Define nuclear fission and fusion reactions.
14. List some renewable energies.

**EXERCISE – IV**

**FOR SCHOOL EXAM.**

1. What are main disadvantages of using fossil fuels and how can we minimize it?
2. What causes acid rain?
3. Write the working of a hydro power plant with heat diagram?
4. What are the limitations of constructing dams across rivers?
5. What is the composition of bio-gas and the matter rich in the slurry left behind in the bio-gas plant?
6. With a neat diagram of a wind mill write its construction and working?
7. Define solar constant and give its value on the upper atmosphere and on the lower atmosphere?
8. What are the advantages and disadvantages of a solar cell?
9. What are the limitations of using solar cell?
10. What factors make a solar cell very expensive?
11. What is ocean thermal energy and how is it harnessed?
12. What is OTEC?
13. What is the minimum requirement to operate the OTEC system?
14. What are the limitation of harnessing Geo-thermal energy?
15. What is the major hazard of nuclear power generation?

**EXERCISE – V**

**FOR SCHOOL EXAM.**

**SECTION-A**

• **Fill in the blanks**

1. Hydro power plants convert the potential energy of falling water into \_\_\_\_\_.
2. The phenomena, in which, the nucleus of a heavy atom, when bombarded with low-energy neutrons, can be split apart into lighter nuclei, is called \_\_\_\_\_.



**SECTION-B****• Multiple choice question with one correct answers**

1. The word 'energy crisis' stands for
 

(A) Energy destruction	(B) Energy creation
(C) Conversion of energy from usable form to less usable form	(D) None of these
2. Device that converts the potential energy of flowing water into electricity is
 

(A) Solar cooker	(B) Thermal power plant
(C) Hydro power plant	(D) Bio-gas plant

**SECTION-C****• Assertion & Reason**

Instructions: In the following questions as Assertion (A) is given followed by a Reason (R). Mark your responses from the following options.

- (A) Both Assertion and Reason are true and Reason is the correct explanation of 'Assertion'  
 (B) Both Assertion and Reason are true and Reason is not the correct explanation of 'Assertion'  
 (C) Assertion is true but Reason is false  
 (D) Assertion is false but Reason is true
1. **Assertion:** In nuclear fission, a tremendous amount of energy is released if the mass of the original nucleus is just a little more than the sum of the masses of the individual products.

**Reason:** The difference in mass,  $Dm$ , between the original nucleus and the product nuclei gets converted to energy  $E$  according to equation

$$E = \Delta m C^2$$

where  $C$  is speed of light in vacuum.

**SECTION-D****• Match the following (one to one)**

**Column-I** and **column-II** contains **four** entries each. Entries of column-I are to be matched with some entries of column-II. Only One entries of column-I may have the matching with the same entries of column-II and one entry of column-II Only one matching with entries of column-I

**1. Column-I****(Device)**

- (A) Hydro power plants
- (B) Wind mill
- (C) Solar cell
- (D) Ocean-thermal-energy conversion plants

**Column-II****(Limitation)**

- (P) Efficient commercial exploitation is difficult
- (Q) Special grade silicon is limited
- (R) Wind speed should higher than 15 km/h
- (S) Large eco-systems are destroyed

**EXERCISE – VI****FOR SCHOOL EXAM.****SECTION-A****• Multiple choice question with one correct answers**

1. The major source of energy in India is –
 

(A) Nuclear	(B) Petroleum	(C) Hydro	(D) Coal
-------------	---------------	-----------	----------
2. Bio-gas is produced in a bio-gas plant, by decomposition of complex compounds of the cow-dung slurry. This process is done by : Micro-organism in the
 

(A) Presence of Oxygen	(B) Absence of Oxygen
------------------------	-----------------------



## **SECTION-B**

- **Multiple choice question with one or more than one correct answers**

1. Limitations in harnessing the kinetic energy of flowing water in hydro power plants is/are
    - (A) The speed of flowing water should higher than 15 km/hr
    - (B) The dam's can be constructed only in a limited number of places
    - (C) Large ecosystems are destroyed when submerged under the water in dams
    - (D) The dams need a high level of maintenance

SECTION-C

- Comprehension

## **Passage-1**

The solar energy reaching unit area at outer edge of the earth's atmosphere exposed perpendicularly to the rays of the sun at the average distance between the sun and earth is known as the solar constant. It is estimated to be approximately  $1.4 \text{ Kj per second per square metre}$  or  $1.4 \text{ Kw/m}^2$ . A rocket is flying at the outer edge of earth's atmosphere. Sun rays are incident perpendicularly on the metal surface of rocket of area  $10 \text{ m}^2$ .

1. Solar energy incident on metal surface in 10 sec. is  
(A) 1.4 KJ                    (B) 14 KJ                    (C) 140 KJ                    (D) None of these
  2. In how much time will metal surface receive 42 KJ of solar energy.  
(A) 3 sec                    (B) 30 sec                    (C) 300 sec                    (D) None of these
  3. Solar energy received by unit area of metal surface in 10 sec. –  
(A) 1.4 KJ                    (B) 14 KJ                    (C) 140 KJ                    (D) None of these

## **SECTION-D**

- Match the following (one to many)

**Column-I** and **column-II** contains **four** entries each. Entries of column-I are to be matched with some entries of column-II. One or more than one entries of column-I may have the matching with the same entries of column-II and one entry of column-II may have one or more than one matching with entries of column-I.

### 1. Column I

- (A) Hydro power plants
  - (B) Solar Cell
  - (C) Thermal power plant
  - (D) Wind mill

**Column II**

- (P) Produces electricity
  - (Q) Converts solar energy into electric energy
  - (R) Converts potential energy of falling water into electricity
  - (S) Converts kinetic energy of air into electricity



# Answers

## EXERCISE-III

### SECTION-A

1. electricity 2. nuclear-tission

### SECTION-B

1. (C) 2. (C)

### SECTION-C

1. (A)

### SECTION-D

1. (A)-(S),(B)-(R),(C)-(Q),(D)-(P)

## EXERCISE-IV

### SECTION-A

1. (D) 2. (B)

### SECTION-B

1. (B,C)

### SECTION-C

1. (C) 2. (A) 3. (B)

### SECTION-D

1. (A)-(P,R), (B)-(P,Q), (C)-(P), (D)-(P,S)

\*\*\*\*\*

